Hobby Electronics

FEBRUARY '82

ISSN 0142-6192

65p

For A Down-To-Earth Approach To Electronics

Making Tracks

Home-Brew PCBs Made Easy

D.I.Y. PROJECTS

- TV/FM Aerial Amplifier
- Noiseless Fuzz Box
- Sound Switch

Special Offer•Special Offer•Special Offer•Special Offer

No-Mess PCB Etching Kit, including Resist-Pen, PCB Cleaner and TWO Blank Printed Circuit Boards!

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INVEST 60p AND MAKE £2.40 net profit

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Buy Ambit's new concise component catalogue and get £1 vouchers. Use them for a £1 discount per £10 spent. But even without this, you will still find WR&E offers the low prices, fast service and technical support facility second to none.

Here are some examples from the current issue:

I.C. SOCKETS

A range of high quality, low cost, low profile DIL sockets ideally suited for both the OEM and hobbyist. All types feature double sided phospher bronze contacts, tin-plated for low contact resistance.

8 x 0.3"	12p	22 x 0.3"	20p
14 x 0.3"	13p	22 x 0.4"	20p
16 x 0.3"	13p	24 x 0.6"	22p
18 x 0.3"	18p	28 x 0.6"	25p
20 x 0.3"	19p	40 x 0.6"	35p
20 x 0.4"	19p	42 x 0.6"	38p

DISCRETES

BC237	8p	BC556	12p		
BC238	8p	BC550	12p	2SK168	35p
ZTX238	9p	BC560	12p	J310	69p
BC239	8p	BC639	22p	J176	65p
BC307	8p	BC640	23p	40823	65p
BC308	8p	2SC1775A	22p	3SK45	49p
BC309	8p	2SA872A	18p	3SK51	54p
BC413	10p	2SD666A	30p	3SK60	58p
BC414	11p	2SB646A	30p	3SK88	99p
BC415	10p	2SD668A	30p	MEM680	75p
BC416	11p	2SB648A	40p	BF960	99p
BC546	12p	BF256	38p	BF961	70p
		2SK55	28p	BF963	99p

VOLTAGE REGULATORS

78XX1A TO-220 pos	0.58
79XX1A TO-220 neg	0.60
78G 1A TO-220 adj pos	1.10
78G 1A TO-3 adj pos	3.95
78H5A TO-3 5v pos	4.25
78H5A TO-3 12v pos	5.45
78HG5A TO-3 adj pos	7.45
79HG5A TO-3 adj neg	7.45
LM317.5A adj pos	1.30
LM337.5A adj neg	1.75
78S401.5A adj pos sw reg	1.20

XTALS

1MHz	3.00
3.2768MHz	2.00
4MHz	1.70
4.194MHz	1.70
4.43MHz	1.25
5MHz	2.00
6.5536MHz	2.00
7MHz	2.00
8MHz	2.00
9MHz	2.00
10MHz	2.00
11MHz	2.00

Prices shown exclude VAT. Postage 50p per order (UK). ACCESS/BARCLAYCARD may be used with written or telephone orders - official MA details on application, and a special prize for those who read our ads carefully - a free 4 or 8MHz crystal filter with every CPU IC you buy - just clip out the paragraph and attach it to your order. E&OE.

CMOS

4000	0.13
4001	0.13
4002	0.13
4007	0.15
4008	0.70
4008AE	0.80
4009	0.30
4010	0.30
4011AE	0.24
4011	0.15
4013	0.32
4015	0.64
4016	0.30
4017	0.45
4019	0.38
4020	0.58
4021	0.68
4022	0.64
4023	0.15
4024	0.45
4025	0.15
4026	1.05
4027	0.50
4028	0.50
4029	0.75
4030	0.35
4035	0.75
4040	0.68
4042	0.58
4043	0.65
4043AE	0.93
4044	0.64
4046	0.69
4047	0.69
4049	0.30
4050	0.30
4051	0.65
4052	0.65
4053	0.65
4054	1.30
4055	1.30
4056	1.30
4059	5.75
4060	0.88
4063	1.15
4066	0.34
4067	4.30
4068	0.18
4069AE	0.18
4070	0.18
4071	0.18
4072	0.18
4073	0.18
4075	0.18
4076	0.60
4077	0.18
4078	0.18
4081	0.18
4082	0.18
4093	0.41
4099	0.93
4175	0.90
4502	0.79
4503	0.48
4506	0.63
4507	0.38
4508	1.95
4510	0.66
4511	0.66
4512	0.70
4514	1.45
4515	1.45
4516	0.75
4518	0.40
4520	0.75
4521	1.60
4522	0.89
4527	0.89
4528	0.78
4529	0.89
4531	0.85
4532	1.20
4534	5.30
4536	3.00
4538	0.97
4539	0.89
4543	1.05
4549	3.50
4553	3.20
4554	1.30
4555	0.48
4556	0.53
4557	2.30
4558	0.89
4559	3.80
4560	1.75
4561	2.18
4562	0.89
4566	3.80
4568	1.45
4569	1.50
4572	1.95
4580	3.25
4581	1.50
4582	1.65
4583	0.80
4584	0.45
4585	0.45
4702	4.50
4703	4.48
4704	4.24
4705	4.24
4706	4.50
4720	4.00
4723	0.95
4724	0.95
4725	2.24
40014	0.54
40085	0.99
40098	0.54
40106	0.69
40160	0.68
40161	0.69
40162	0.69
40163	0.69
40174	0.69
40175	0.69
40192	0.75
40193	0.75
40194	0.69
40195	0.69

TTL N

7400N	0.10
7401N	0.10
7402N	0.20
7403N	0.11
7404N	0.12
7405N	0.12
7406N	0.22
7407N	0.22
7408N	0.15
7409N	0.15
7410N	0.12
7411N	0.18
7412N	0.19
7413N	0.27
7414N	0.51
7416N	0.27
7417N	0.27
7420N	0.13
7421N	0.28
7423N	0.22
7425N	0.22
7426N	0.22
7427N	0.22
7430N	0.13
7432N	0.23
7437N	0.22
7438N	0.22
7440N	0.14
7441N	0.54
7442N	0.42
7443N	0.62
7444N	0.62
7445N	0.62
7446N	0.62
7447N	0.62
7448N	0.56
7450	0.14
7451N	0.14
7453N	0.14
7454N	0.14
7460N	0.14
7470N	0.28
7472N	0.27
7473N	0.28
7474N	0.28
7475N	0.35
7476N	0.30
7480N	0.26
7481N	0.20
7482N	0.75
7485N	0.75
7486N	0.24
7489N	1.05
7490N	0.30
7491N	0.55
7492N	0.35
7493N	0.35
7494N	0.70
7495N	0.60
7496N	0.45
7497N	1.40
74100	1.10
74104	0.62
74105	0.62
74107	0.26
74109N	0.35
74110N	0.54
74111N	0.68
74112N	1.70
74116N	1.98
74118N	0.85
74119N	1.20
74120N	0.95
74121N	0.34
74122N	0.34
74123N	0.40
74125N	0.40
74126N	0.40
74128N	0.65
74132N	0.50
74136N	0.65
74141N	0.45
74142N	1.85
74143N	2.50
74144N	2.50
74145N	0.75
74147N	1.50
74148N	1.09
74150N	0.79
74151N	0.55
74153N	0.55
74154N	0.55
74155N	0.55
74156N	0.55
74157N	0.55
74159N	1.90
74160N	0.55
74161N	0.55
74162N	0.55
74163N	0.55
74164N	0.55
74165N	0.55
74166N	0.70
74167N	1.25
74170N	1.25
74173N	1.10
74174N	0.75
74175N	0.75
74176N	0.75
74177N	0.75
74178N	0.90
74179N	1.35
74180N	0.75
74181N	1.22
74182N	0.70
74184N	1.20
74185N	1.20
74188N	3.00
74190N	0.55
74191N	0.55
74192N	0.55
74193N	0.55
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74196N	0.55
74197N	0.55
74198N	0.85
74199N	1.00
74221N	1.00
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74251N	1.05
74265N	0.66
74273N	2.67
74278N	2.49
74279N	0.89
74283N	1.30
74284N	3.50
74285N	3.50
74290N	1.00
74293N	1.05
74297N	2.36
74298N	1.85
74365N	0.85
74366N	0.85
74367N	0.85
74368N	0.85
74390N	1.85
74393N	1.85
74490N	1.85

74LSN

74LS00N	0.11
74LS01N	0.11
74LS02N	0.12
74LS03N	0.12
74LS04N	0.14
74LS05N	0.14
74LS08N	0.14
74LS09N	0.14
74LS10N	0.13
74LS11N	0.14
74LS12N	0.15
74LS13N	0.28
74LS14N	0.46
74LS15N	0.14
74LS20N	0.13
74LS21N	0.15
74LS22N	0.15
74LS26N	0.18
74LS27N	0.14
74LS28N	0.19
74LS30N	0.13
74LS32N	0.14
74LS33N	0.16
74LS37N	0.15
74LS38N	0.16
74LS40N	0.13
74LS42N	0.33
74LS47N	0.39
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74LS51N	0.14
74LS54N	0.15
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74LS74N	0.18
74LS75N	0.28
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74LS157N	0.33
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74LS160N	0.40
74LS161N	0.40
74LS162N	0.40
74LS163N	0.40
74LS164N	0.46
74LS165N	1.20
74LS166N	0.80
74LS168N	0.85
74LS169N	0.85
74LS170N	1.40
74LS173N	0.70
74LS174N	0.55
74LS175N	0.55
74LS181N	1.20
74LS183N	1.75
74LS189N	1.28
74LS190N	0.56
74LS191N	0.56
74LS192N	0.56
74LS193N	0.59
74LS194N	0.39
74LS195N	0.39
74LS196N	0.55
74LS197N	0.65
74LS200N	3.45
74LS202N	3.45
74LS221N	0.60
74LS240N	0.99
74LS241N	0.99
74LS242N	1.65
74LS243N	1.65
74LS244N	0.83
74LS245N	1.50
74LS247N	1.35
74LS248N	1.35
74LS249N	1.35
74LS251N	0.46
74LS253N	0.46
74LS257N	0.55
74LS258N	0.39
74LS259N	0.39
74LS260N	0.70
74LS266N	0.24
74LS273N	0.90
74LS275N	3.20
74LS279N	0.35
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74LS283N	0.44
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74LS293N	1.30
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74LS365N	0.35
74LS366N	0.35
74LS367N	0.35
74LS368N	0.35
74LS373N	0.78
74LS374N	0.78
74LS375N	1.15
74LS377N	1.99
74LS378N	1.40
74LS379N	2.15
74LS384N	2.50
74LS385N	4.20
74LS386N	0.29
74LS390N	0.68
74LS393N	0.61
74LS395N	2.10
74LS396N	1.99
74LS398N	2.75
74LS399N	2.30
74LS445N	1.40
74LS447N	1.95
74LS490N	1.10
74LS668N	1.05
74LS669N	1.05
74LS670N	1.70

RAM

2102	1.70
2112	3.40
2114/2	1.49
4027	5.78
4116/2	1.59
4116/3	1.49
4864P	12.50
6116P-3	12.50
6116P-4	11.25
8264	12.50

74CXX

74C00	0.20
74C02	0.20
74C04	0.20
74C08	0.20
74C10	0.20
74C14	0.55
74C20	0.20
74C30	0.20
74C32	0.20
74C42	0.80
74C48	1.03
74C73	0.50
74C74	0.50
74C76	0.48
74C83	0.98
74C85	0.98
74C86	0.26
74C89	2.68
74C90	0.80
74C93	0.80
74C95	0.94
74C107	0.48
74C151	1.52
74C154	2.26
74C157	1.52
74C160	0.80
74C161	0.80
74C162	0.80
74C163	0.80
74C164	0.80
74C165	0.84
74C173	0.72
74C174	0.72
74C175	0.72
74C192	0.80
74C193	0.80
74C195	0.80
74C200	4.52
74C221	1.06
74C901	0.38
74C902	0.38
74C903	0.38
74C904	0.38
74C905	5.64
74C906	0.38
74C907	0.38
74C908	0.84
74C909	1.52
74C910	3.62
74C914	0.86
74C918	0.98
74C925	4.32
74C926	4.32
74C927	4.32

Processors 8080 series

8080AFC/2	3.11
8212	1.70
8214	3.50
8216	1.41
8224	1.85
8251	4.26
8255	3.97

6800/6809

6800P	3.75
68A00	4.25
68B00	4.75
6802	5.55
6809	15.00
6810	1.75
68A10	1.85
68B10	2.04
6820	1.95
6821	1.75
68A21	2.10
68B21	2.34
6840	4.25
68A40	4.55
68B40	4.75
6850	1.75
68B50	2.17
6852	2.47
68A52	2.75
68B52	2.95
68488	5.25

Z80 series

Z80A	4.99
Z80ADRT	7.50
Z80APIO	4.10
Z80ASIO/1	14.00
Z80ASIO/2	14.00
Z80ASIO/9	14.00
Z80CTC	4.00
Z80ACTC	4.50
Z8001	65.00

PROM

2708	2.00
2716	3.55
2532	8.50
2732	8.50

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AMBIT international 200 North Service Road, Brentwood, Essex

Hobby Electronics

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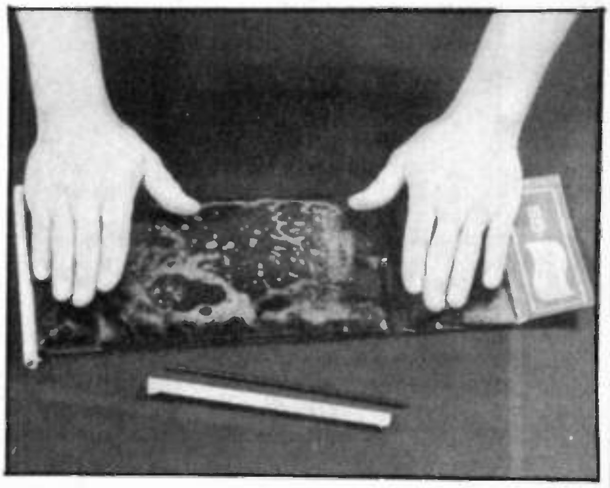
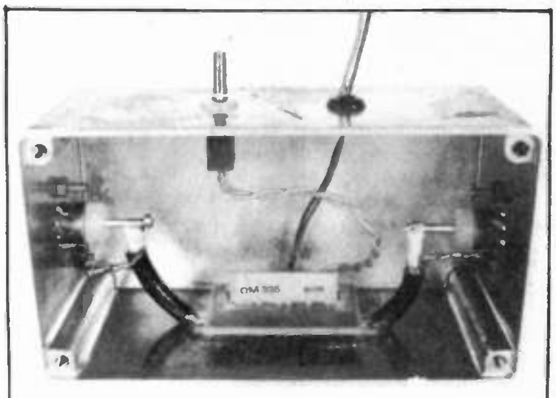
PROJECTS

FEATURES

SPECIALS

REGULARS





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MAGENTA ELECTRONICS LTD.

C106D	58p	2N5457	58p	BFY51	24p
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OA90	9p	AC128	29p	BRY39	48p
OA202	18p	AC141	38p	MPSA65	39p
WO05	33p	AC142	39p	RPY58A	£1 16
W06	47p	AC176	37p	TIP31A	52p
Z5J	£2 92	BC182	11p	TIP32A	83p
IN4001	5½p	BC182L	11p	TIP33A	94p
IN4005	6p	BC183	11p	TIP34A	99p
IN4148	5p	BC184	11p	TIP121	£1 12
IN5404	18p	BC184L	11p	TIP2955	69p
IN5408	19p	BC212	11p	TIP3055	69p
BF244	87p	BC212L	11p	TIS43	38p
MPF102	69p	BC213	11p	TPSA13	35p
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VN67AF	£1 21	BC214L	11p	2N3055	59p
2N3819	28p	BD131	48p	2N3702	11p
2N3820	78p	BFY50	25p	2N3704	11p

¼W CARBON FILM RESISTORS
E12 SERIES. 1R-10M .... 1½p each
MIN. HORIZ. PRESETS. 100R-4M7 .... 12p each
MIDGET POTS. LINEAR. 470R-4M7 37p each
LOG. 4K7-2M3 .... 38p each
SWITCHED POTS. 4K7-1M. LIN. 75p. LOG 70p

POLYESTER (C280) CAPACITORS. 250V
10nF; 15nF; 22nF; 33nF; 47nF 7p each. 68nF; 100nF 8p. 150nF; 220nF 12p. 330nF 15p. 470nF 20p. 680nF 26p. 1µF 33p. 1·5µF 49p. 2·2µF 65p.

SUB MINIATURE PLATE CERAMICS, 63V
Values in pF; 2·2; 3·3; 4·7; 5·6; 6·8; 8·2; 10; 15; 22; 33; 47 & 56pF 7p each. 68pF; 100pF 7p each. 150pF; 220pF; 330pF 11p each. 390pF, 470pF. 1000pF 5p each. 2200pF 8p each. 3300pF, 4700pF 7p each. 10nF 13p. 100nF 22p. 47nF 14p.

ELECTROLYTIC CAPACITORS
AXIAL Leads: 1µF/16V 11p; 1µF/63V, 1µF/100V 12p; 2·2µF/63V, 3·3µF/63V, 4·7µF/63V 12p; 10µF/16V 11p; 10µF/25V, 10µF/63V 12p; 22µF/10V, 22µF/25V 12p; 22µF/63V 15p; 33µF/40V, 47µF/25V 12p; 47µF/40V 15p; 47µF/63V 18p; 100µF/16V 12p; 100µF/25V 15p; 100µF/40V 18p; 100µF/63V 29p; 220µF/10V 15p; 220µF/25V 19p; 470µF/16V 29p; 470µF/25V 36p; 470µF/40V 55p; 680µF/16V 32p; 1000µF/10V 30p; 1000µF/16V 33p; 1000µF/25V 48p; 1000µF/40V 58p; 1000µF/63V 79p; 2200µF/10V 39p; 2200µF/25V 64p; 2200µF/63V £1 10.

CMOS

4001	20p	LM386N	92p
4011	20p	LM387	£1.10
4013	32p	LM389N	£1.10
4017	62p	LM1830	£1.98
4020	65p	LM3909	82p
4024	60p	LM3914	£2.99
4069	20p	LM3916	£3.95
4081	20p	MC3340	£2.15
4093	38p	NE570N	£4.98
40174	£1.20	NE571N	£4.84
4522	£1.25	OM335	£8.98
555	26p	SN76477	£2.59
556	79p	TL064	£1.64
741	22p	TL071	47p
CA3130E	98p	TL082	74p
CA3140E	52p	TL083	£1.52
HA1388	£3.20	TL084	£1.54
ICL7611	88p	TL430	95p
ICM7555	99p	U2378	£1.69
LF351N	56p	U2678	£2.20
LF353N	99p	ULN2283	£1.57
LF355	£1.14	2N414	98p
LF356	£1.15	2N419CE	£2.21
LM301A	36p	7400	22p
LM317K	£3.20	7447	£1.14
LM335	£1.16	7490	55p
LM380N	89p	7495	80p

OPTO
BPX25 .... £2·24
2N5777 .... 60p
ORP12 .... 99p
TIL32 .... 81p
TIL78 .... 74p
LEDS WITH CLIPS
3mm. Red 15p. Green 18p. Yellow 20p.
5mm. Red 16p. Green 28p. Yellow 29p.
FLASHING LED 78p
RECTANGULAR. Red 58p
MAINS PANEL. Neon 32p

ZENER DIODES. 400mW. BZY88. Range 2V7 to 33V. 12p each.

I.C. SOCKETS
8 pin .... 16p 18 pin 22p
14 pin .... 17p 24 pin 48p
16 pin .... 18p 28 pin 45p

SWITCHES
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DRUM SYNTHESISER

From ETI April 81 this superb intrument has two independent percussion channels — each with pitch, noise, decay and level controls. The synthesiser contains a versatile in built sequencer which enables different beat sequences to be programmed using 8 way DIL switches. Beats from either channel may be individually programmed, or combined in any mixture. Once programmed the sequence can be replayed automatically or manually as required. Manual and automatic operation are possible together so that the unit can be played manually with an occasional few bars of automatically sequenced rhythm. A very versatile instrument. Drum Synthesiser Kit less case £39.98, with case £53.56.

See also H.E. Projects Dec 81 — another Drum Synthesiser.

GUITAR NOTE EXPANDER

From ETI April 81. Not just another Fuzz/Sustain Unit. This versatile project can produce overload effects which closely approach the sound of an overdriven valve amp.
Switch selection for: —
1. Overall overdrive
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3. H.F. compression for bass overdrive
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5. Mid frequency expansion
6. H.F. expansion for H.F. accentuation.

All (except overall overdrive) have variable effects control. Guitar Note Expander Kit £16.47, less case £11.25.

SOUND BENDER

From ETI Oct 81. A very effective 'Ring Modulator' sound effects unit. This design incorporates its own variable frequency oscillator with sine or triangular waveform, and a 4 quadrant multiplier circuit.
A mix control allows the modulated signal to be mixed with the straight through signal. Ideal for outer space, voice and music effects. Just connect a signal source and a power amplifier and speaker.
Sound Bender Kit £20.76, less case £15.76.

HAND CLAP SYNTHESISER

Adds a new interesting effect to your music. 6 controls enable wide variation of the clap sound to accompany different types of music. The 'clap' may be initiated by a push button switch or any external push-to-make switch e.g. a footswitch. Alternatively triggering may be via a microphone input to the unit so that a signal from a mic placed near to a snare drum will initiate the clap.
Hand Clap Synthesiser Kit £29.98, less case £23.58.

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by Tom Duncan

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ADVENTURES WITH ELECTRONICS

by Tom Duncan

An easy to follow book suitable for all ages. Ideal for beginners. No soldering, uses an S-Dec breadboard. Gives clear instructions with lots of pictures. 16 projects—including three radios, siren, metronome, organ, intercom, timer, etc. Helps you learn about electronic components and how circuits work. Component pack includes an S-Dec breadboard and all the components for the projects.
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MONITOR

Multitudes of Meters

Electronics enthusiasts are now able to get their hands on the Sanwa range of high quality multimeters through Toolmail Ltd's mail order service. Prices start at £20 for multimeters which feature a wide range of performance specifications.

Sanwa boasts the widest range of multimeters anywhere in the world, with many of its products regularly specified for use in industry and government in several countries.

For ~~a full~~ colour brochure and details of selected models, contact Toolmail Ltd, Parkwood Industrial Estate, Sutton Road, Maidstone, Kent ME15 9LZ Tel: Maidstone (0622) 672736. The catalogue also contains many useful tools of interest to the electronics hobbyist.

The Case of the In-Car Cassette

To make tape cassette storage easier, more organised — and therefore safer — Cambrasound Ltd offer the Tapemate, the in-car tape holder.

Tapemate is made of impact-resistant material and is easily attached to the dashboard, behind the visor, or to the door of the car by means of velcro and self-adhesive strips (supplied). Tapes stay secure in the holder thanks to a locking device which eliminates the problem of discovering your favourite tape on the floor, mutilated beyond recognition.

For details write to Cambrasound Ltd, Foreden House, 4/10 North Road, Islington, London N7 9HN or phone (01) 607 8141.

Holy Holography!

Light Fantastic, Britain's first gallery of holography, was opened by Sir Hugh Casson, President of the Royal Academy, on the 3rd December 1981. The inaugural display featured forty holographs (three dimensional images created by laser beams) which showed a cross-section of holography from works of art to engineering and promotional holographs, as well as a display of 'laser writing' advertising.

The gallery is located at the centre of Covent Garden at No. 48 South Row (opposite Southampton Street), and features the most comprehensive exhibit of holography in Britain since the successful Light Fantastic exhibitions in 1977 and 1978.

Light Fantastic will be Britain's premier showcase of holography showing the best of holography in terms of technical achievement, creative interpretation and pure fascination.

The gallery is open to the public from 10 am to 8 pm each day (except Monday) with an entrance fee of £1 for adults and 60p for children. Holographs are on sale at the gallery (from £5 to £9001) along with a wide selection of literature on the subject of holography.

Modular Modes

ILP Electronics of Canterbury, designers and manufacturers of encapsulated audio modules, have announced the addition of four new stereo modules to their family.

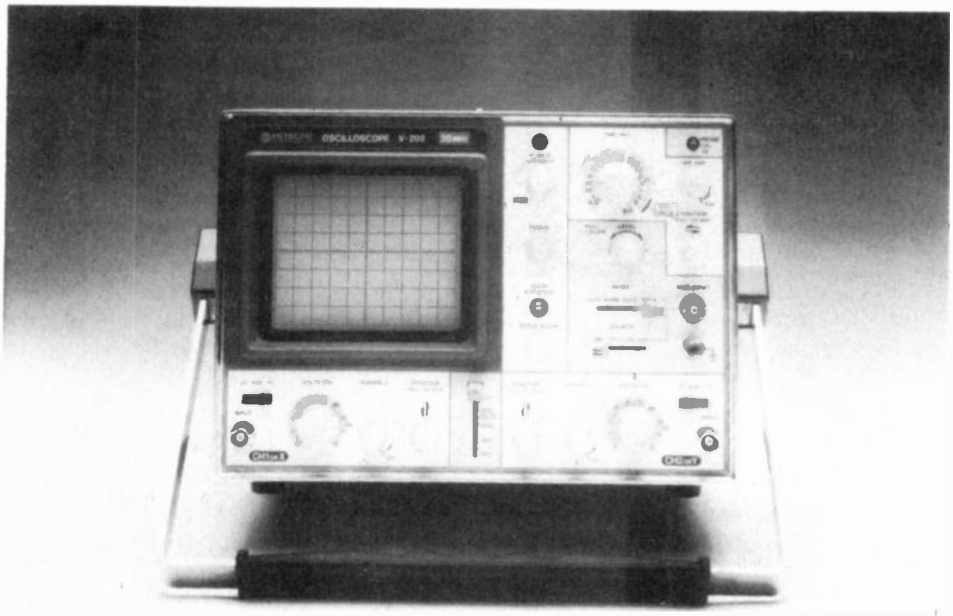
The first of the new units is the HY74 stereo mixer, which offers sophisticated five-into-one mixing facilities on each of the two channels. Used in combination with an appropriate pre-amp and power amp, it is possible to create a quality mixer-amplifier at a reasonable price. The cost of the HY74 itself is £11.45 plus VAT.

An alternative is the new HY75 stereo pre-amp with built-in mixer for two signals on each of two channels. The HY75 offers separate bass, mid range and treble controls and costs £10.75 plus VAT.

The other new modules are the HY76, a four-way stereo switch matrix, and the HY77, a combined VU meter drive/LED overload driver module with programmeable gain.

For the future, ILP are promising new products for the new legal CB market.

Contact ILP, Graham Bell House, Roper Close, Canterbury, Kent CT2 7EP. Tel: (0227) 54778 for details.



New 'Scope

The Hitachi V-202 is a low cost dual trace oscilloscope with a full range bandwidth of 20 MHz. Both vertical channels have a maximum sensitivity of 1mV/division, and variable controls allow intermediate sensitivity between attenuator steps.

The vertical deflection system provides sweep speeds up to 20 nsec/div with X10 magnification, a comprehensive triggering system with bright line auto mode and an active sync separator for video signals.

The 5¼ inch rectangular CRT has an internal (parallax free) graticule with variable scale illumination, and automatic focus compensation eliminates the need to reset the focus control when altering the brightness.

The cost is £260, plus VAT, from the distributor, Reltech Instruments, Coach Mews, St. Ives, Huntingdon, Cambs. PE17 4BN, Tel: (0480) 63570.

Robot Invasion (continued). . .

Systems Control Company and Acorn Computers have designed and developed a small "army" of eight robots, for use in education, research, and light industry. Appropriately called'Smart-Arms', they are similar to a human arm, with a gripping hand, wrist, shoulder and elbow movements.

The 'baby' of the range is the 4E (Educational) model, which has elbow, shoulder rotation and grip movements and is suited for experimental projects; the more sophisticated 6E and 6ES, have a lifting capacity of 200g and a maximum reach of 300 mm. Top of the range are the 6R and 6I series; the 6R robot is designed for research use while the 6I is a lower-priced, industrial version.

The robots are completely programmable — the software is in BASIC. Time delays and jumps between points in a sequence of movements can be programmed, and complete sequences may be stored on cassette.

With prices starting at £430 (for the 4E), the Smart Arms will be of great interest to keen students of rototics. For all the details contact Systems Control 30 Thirsk Road, Northallerton, North Yorkshire, DL6 1PH, Tel: (0609) 70643, or Acorn Computers, Tel: Cambridge (0223) 245 200.

Soft Competition

Here's a contest for computer buffs who know the BASICs — Sinclair Research Ltd is sponsoring a special award scheme to help meet the need for more ZX81 educational software. The prizes are six ZX Printers, for the best programs accepted by the end of March 1982 for the Mini and Micro Computer Users in Secondary Education (MUSE) software library.

MUSE is a national organisation which co-ordinates educational computer activities in primary and secondary schools, teacher training institutions and colleges. MUSE and the Educational ZX80/81 Users Group (EZUG) will administer the scheme and, in collaboration with Sinclair, judge submissions in the categories at primary maths and science, other primary, secondary maths, science and computing, other secondary and special education.

Sinclair's sponsorship of this competition is the result of their interest in supporting, wherever possible, the development of educational software. The company has already sold ZX81s to more than 2300 secondary schools under its subsidised purchase scheme.

Entries or inquiries should be sent to Eric Deeson, EZUG Organiser, Highgate School, Birmingham B12 9DS. Closing date is February 27th, so you'll have to be quick!

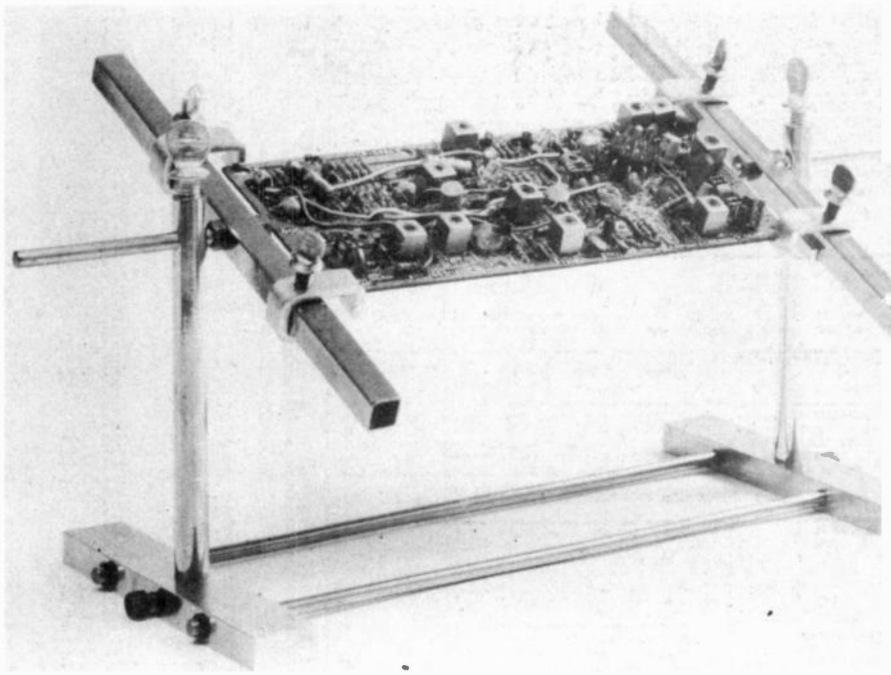
On the Groove

Seeing is believing, so they say . . . and pictures don't lie, but if you can't believe your eyes, you'll have to trust your ears when you hear the Record Runner motoring across your favourite album. Yes, it does look like a micro Volkswagen Minibus, but it contains a speaker built into the roof and a stylus where the exhaust should be . . . and it plays records without the help of any stereo equipment whatsoever. Just place it on the vinyl and the Record Runner will motor around the disc, making music as it goes.

The perfect present for the man who has everything else? See it and believe it, at The Video Palace, 62/64 Kensington High Street, W8.

MONITOR

Spare Hands



Serious HE project builders will be familiar with the traditional problem of the Third Hand: how to hold a printed circuit board, a sensitive component, a heat sinking clamp, solder *and* the soldering iron with only the regulation two hands. This outstanding problem for the electronic constructor has been solved by a British manufacturer, Carlton Nichol & Co. Ltd, who have released two new printed circuit board holders. Both models are made from aluminium and plated steel, and allow easy rotation through 360 degrees with positive locking at any angle. The boards are firmly held in any convenient position, leaving both hands free.

The CNC 6 will take boards of up to 10" x 7", held in position by spring-loaded clamps, while the larger CNC 9 will hold boards as big as 8" x 8" in sliding vee clamps which minimise damage to the surfaces but allow maximum ease of access.

An optional anti-static foam pad allows the insertion of a number of sensitive components before the board is flipped for soldering. The pad is on a backing plate and clips onto the rotating arms of the PCB holder.

The listed prices including VAT, of these handy holders are £13.80 for the CNC 6, £15.95 for the CNC 9, and the pad is £9.20 — but just think of the savings on burn ointment, and the goodwill you will gain when it is no longer necessary to ask someone to ". . . just hold this a moment, please . . ." as you wave a hot iron within millimetres of their trembling fingers!

The PCB holders are available direct from the manufacturers — Carlton Nichol & Co. Ltd., Goldkey Industrial Estate, Kelvedon, Essex.

Disabled Aid

Undergraduate apprentices at British Aerospace Dynamics Group, Bristol Division, have built a robot arm and a tone operated telephone in a training exercise. Both, with further development, could be used by the disabled.

The arm is electro-mechanical, lifts up to half a kilogramme, can be programmed to repeat simple functions, move in three dimensions, and rotate through 360 degrees.

The tone operated telephone is remotely controlled by three separate whistles which can be positioned away from the telephone. The whistle tones enable the desired number to be obtained, displayed and electronically fed into the telephone. A directional microphone enables the telephone to be answered from a distance.

These projects were the result of the collaboration of seven apprentices who were given abudget of £200 for each project and a set of specifications.

For further information contact T. C. Bickerton, Public Relations Manager, British Aerospace Dynamics Group, Bristol Division, PO Box 5, Filton Bristol BS12 7QW. Tel: Bristol 693831.

Jogging Time

Jogging may be hazardous to your health yet, despite this, masochists everywhere persist in pounding the path, risking shin splints, pulled muscles, ankle-eating dogs and asthma, in their quest for fitness.

Riding high on the myths ofprosperity through pacing, new products are constantly creeping into the market; now Casio Electronics has made the running with one of their multi-mode watches.

The model J100 features what Casio calls "a novel 'pacer' mode," designed to help runners get the most from their tortuous activity. Before donning jogging togs, you simply feed the watch information about your length of stride and preferred running rate. The stride length is set digitally and is measured in either feet and inches or in meters. Running rate is expressed by audible pips on an adjustable 69-step scale, and is also shown on the display .

Provided a jogger keeps pace with the pips and holds the set stride length, the watch will show target speed, elapsed time, distance traveled, and the number of strides made. Of course the J100 gives the time, day and date, and also includes a 1/100th second stopwatch and an eight-digit, four-function calculator, a daily alarm, and an hourly time signal. Whew! Does anyone make watches that simply tell time?

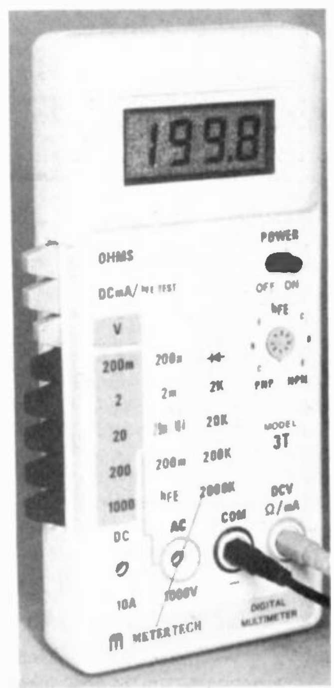
Joggers can huff and puff down to the shop and pick up this new watch for £22.95, although Casio products are often available below this recommended price. For more information contact Casio, 28 Scrutton St, London, EC2A 4TY, Tel: 01-377 9087. But don't say you haven't been warned!

And Now for Something Similar . . .

The new model 3T from Centemp is a battery operated, hand held, 3¼ digit liquid crystal display digital multimeterwith push-button control over six functions in 16 ranges. It measures DC voltage, AC voltage, DC current, resistance, Diode/continuous check and also has a transistor gain measurement facility.

The model 3T can be yours for £43.50 plus VAT.

Contact Centemp, 62 Curtis Road, Whitton, Hounslow, Middx. TW4 5PT. Tel: 01-894 2723.



Makin' Tracks

One of the neatest ways of building up a circuit is on printed circuit board. In this special feature, guest writer Don Keighley shows what a printed circuit board is and how to make your own

PRINTED CIRCUIT BOARDS – PCBs – are used extensively because they provide a neat and reliable way of holding components and of making the necessary connections between them. In the days before PCBs, circuits were built up underneath a large metal chassis with the components strung between connection points – tag strips, they were called – in a seemingly haphazard manner. You only have to look inside an old valve radio or TV to get the point. All electronics manufacturers must have breathed a sigh of relief when PCBs were invented.

PCBs aren't used only in industrial equipment – they are equally suitable for the hobbyist. The difference between commercial/industrial PCBs and those we make at home is really only in the techniques used.

Figure 1 shows the PCB of the Intelligent NiCad Charger project from last month's issue, with the components drawn in to show where they go; Figure 2 shows the same PCB viewed from the bottom. It is quite easy to make a board such as this at home – and shortly, we will explain how it's done.

Board Stiff

Now that you know *why* a PCB is used, let's backtrack a little and see just exactly *what* it is. Any PCB starts life as copper-clad board – a thin base-board (about 2 mm) of insulating material (such as fibre-glass or resin-bonded paper) with an even thinner (about 0.25 mm) copper coating on one side. **Figure 3** shows a cross-section of a piece of copper-clad board. Some highly specialised circuits may be built on boards with copper on both sides – called, naturally, double-sided PCBs.

To turn this copper-clad board into a PCB we have to remove all excess areas of copper, leaving behind only those areas (which make up the foil pattern) that we want. After this it's a simple job to drill the holes and to insert and solder components in their places.

By this time you'll be wondering, no doubt, how you 'remove' the areas of copper which aren't wanted – do you need a laser gun to blast them off the face of the earth? Or perhaps Superman might fly along to save the situation and burn them away with his infra-red vision?

The answer is nothing quite as sci-fi as that I'm afraid; in fact it's all down to pure, old-fashioned school chemistry. You see, copper is a metal and metals are dissolved by acids. So all we have to do is place the board into acid and the areas of unwanted copper will be rapidly dissolved (etched) away. But now we have another problem – surely the acid will etch away the wanted areas as well? Well, it will if we let it. But, if we cover up the wanted copper, in the shape of the required foil pattern (as shown in **Fig. 4**), with acid-resisting material before putting the board into the acid, then those areas will remain un-etched when the rest has disappeared (see **Fig. 5**).

Down To The Nitty-Gritty

By now, you'll have realised that the production of any PCB goes through three stages:

- design of the PCB foil pattern to suit the circuit
- application of resist in the shape of that foil pattern
- etching of the PCB until unwanted copper areas are removed, subsequent removal of etch-resist and drilling of the component holes prior to circuit make-up.

I'm now going to unravel the mysteries of each stage and show you how to set about designing and making your own PCBs.

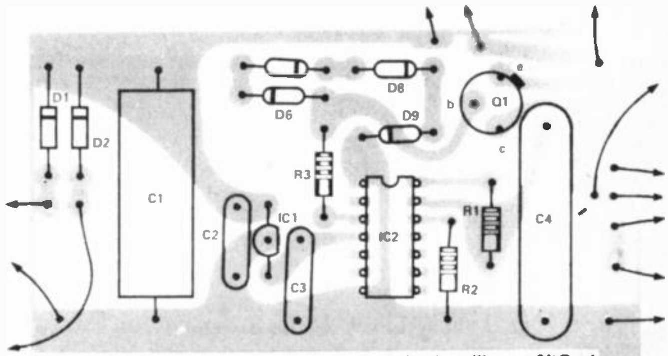
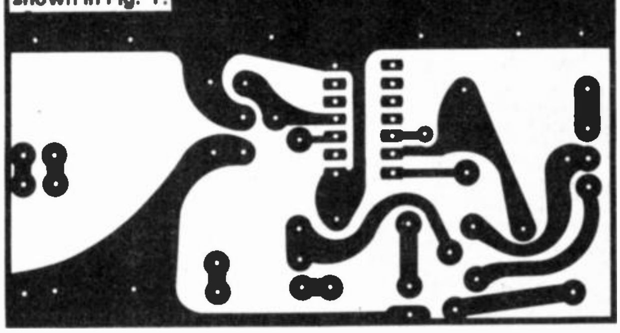


Figure 1. The printed circuit board of the Intelligent NiCad Charger in the January 1982 issue of Hobby Electronics.

Figure 2. A view of the underside of the board shown in Fig. 1.



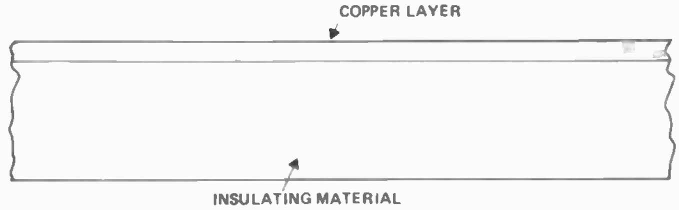


Figure 3. Cross-section of a piece of copper-clad board.

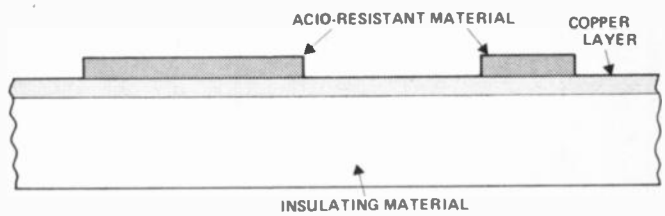


Figure 4. Cross-section of copper-clad board with acid-resistant material applied in the shape of the foil pattern.

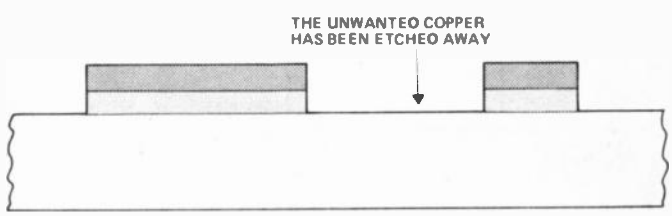
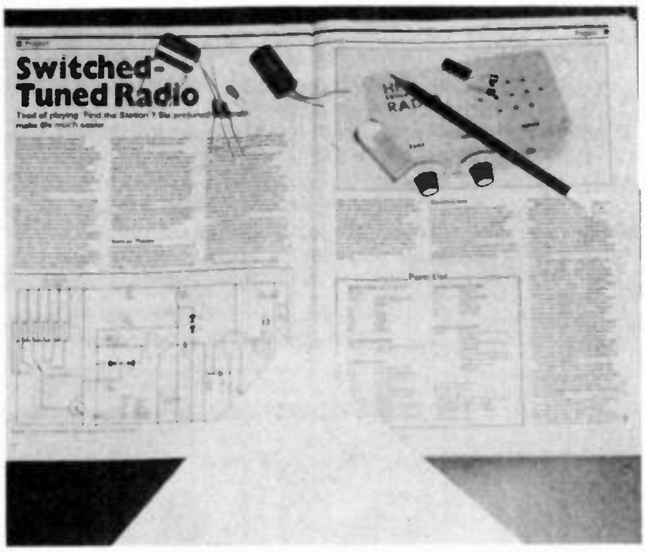


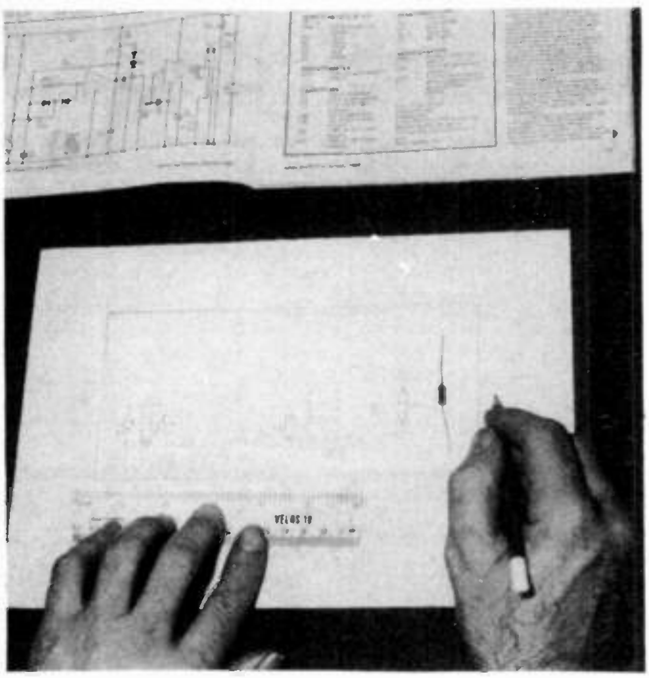
Figure 5. After etching, the unwanted copper is etched away and those areas in the shape of the foil pattern (with acid-resisting material) remain.

Designing Your PCB Foil Pattern

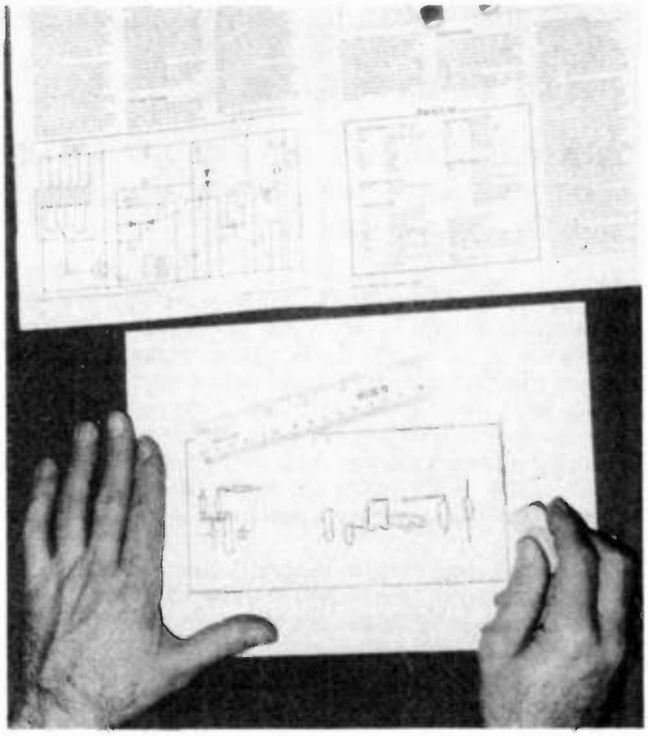
The only things you'll need at this stage are: pencils, a rubber, some paper (plain, graph and tracing) and either: a selection of one of each type of component used — ie one resistor, one transistor, one IC, etc — or their physical dimensions. This is because you need to know how big each component is so that, when you begin the layout of the board, you know what distance to leave between component lead holes. If you attempt more than just a couple of PCB foil pattern designs you'll begin to remember the sizes of the more common components and you will only need to measure the unusual ones.



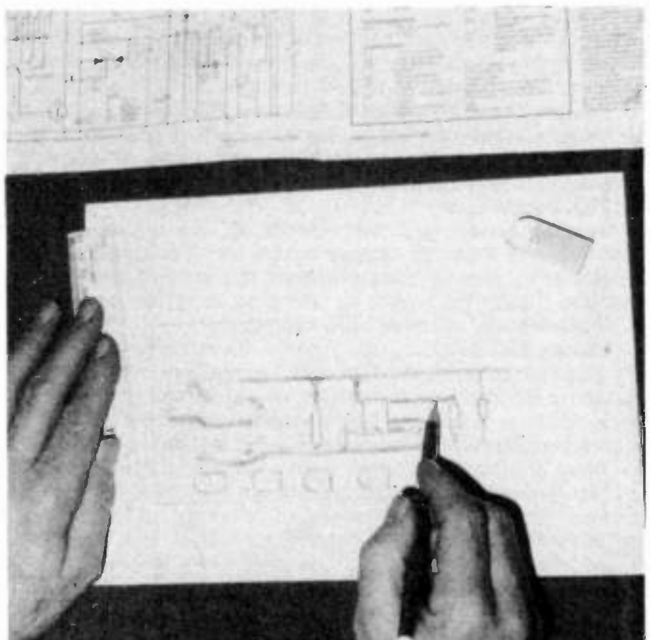
1) Begin by displaying the circuit diagram in front of you, along with a sheet of plain paper. Make sure all components in the diagram are numbered so that as you lay out the foil pattern design on paper you can mark each component's location with its number.
Imagine that the sheet of paper is your PCB. All of the components fit into the 'board' from the top, therefore the 'foil pattern' is underneath and you can't see it directly.



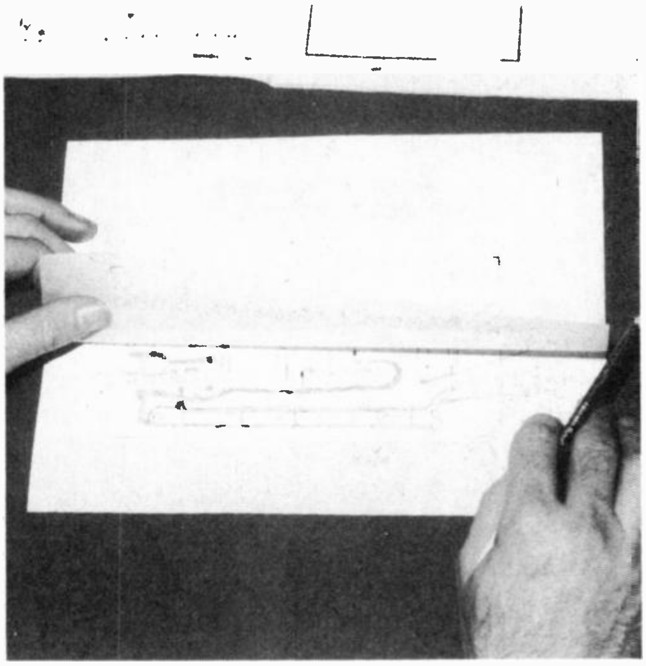
2) Choosing a central component, say an IC, pencil in its approximate shape and mark where its connection leads enter into the paper 'board'. Now, draw another component which is connected to the first component.



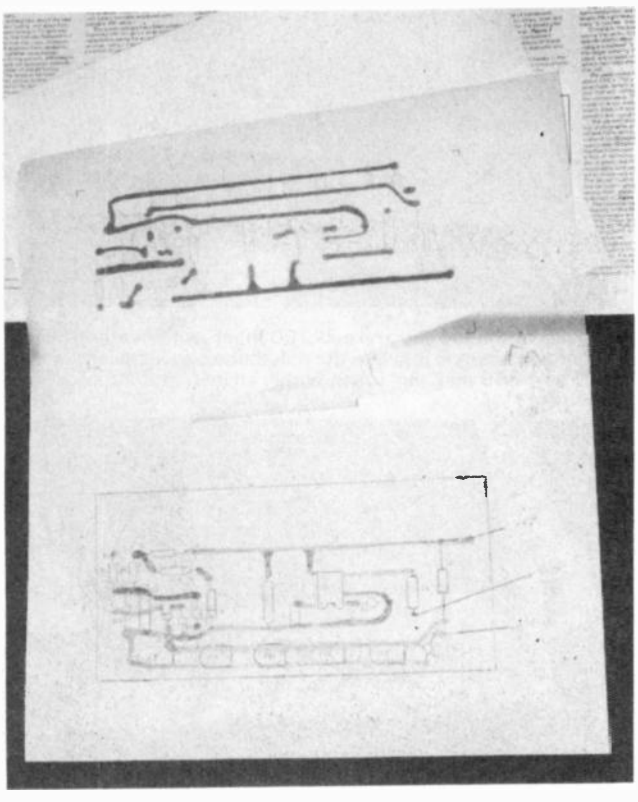
3) When you have drawn a few components on the paper, you can begin to connect them by pencilling-in 'tracks' on the paper, between holes. Don't worry if you get stuck, or even make a mistake; that's why you have the rubber! Rub-out the error and start again.
Don't be afraid to position components close together: a spacing of 2 mm between components is ideal.



4) Remember that the finished PCB will have its foil pattern on the other side to its components, so tracks can actually *pass underneath components*. There is no reason why two, or even three tracks cannot pass underneath a component, *as long as the tracks don't touch* either each other, or the component lead holes.
Draw the remainder of the circuit components on the paper and draw in the remaining tracks to complete your foil pattern.



5) Place a sheet of tracing-paper over a sheet of graph paper and tape the two together along the edges. Now, using the grid of the graph paper to help align components, redraw the layout on the tracing paper. Draw component shapes in one colour of pencil (say, red) and tracks in another colour (say, black). In this way you can instantly tell which is the 'top' and which is the 'bottom' of the board. Check, as you redraw the foil pattern, that it is correct with regard to the circuit diagram.



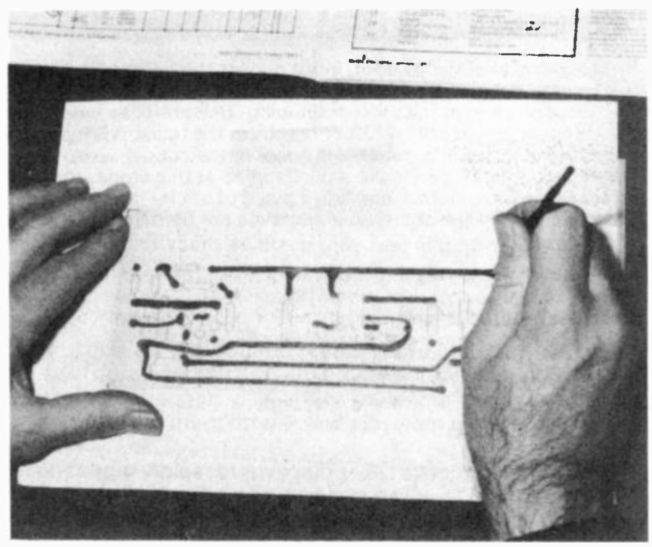
6) The tracing-paper copy of your PCB foil pattern is now your reference. Cut, or pull off, the tape holding it to the graph paper Turn over the tracing-paper, so that you can see the 'underside' of the board — the black connection pattern corresponds to the actual foil pattern layout required on the copper surface of the copper-clad board.

Transferring Your Foil Pattern On To PCB

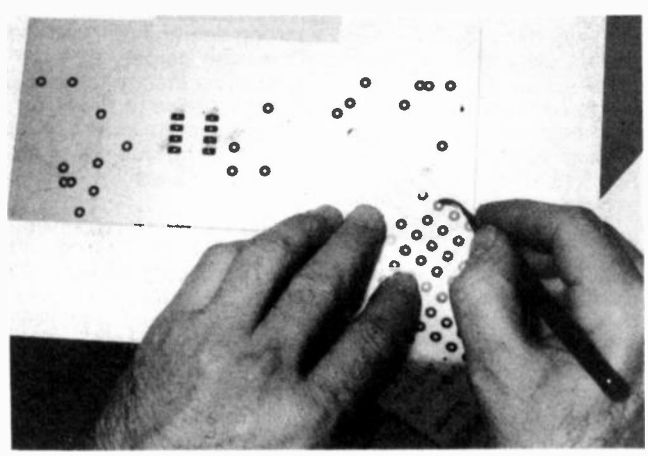
Now that you have the foil pattern, you need to transfer it on to the copper-clad board using etch-resistant materials (resist). This resist can take many forms: the simplest can be ordinary household enamel or gloss paint, applied with a fine brush (messy); the most complex is photograhic resist, developed on the circuit board much like your summer holiday snapshots are developed on film. The one you use will depend on how much you're prepared to pay. You can expect to pay about (gulp) £60 for a basic photographic system: this will let you make first-class PCBs, but it won't do your pocket a lot of good — it's the system which is likely to be used by schools and colleges where large numbers of one-off PCBs are needed.

The poor electronics hobbyist doesn't normally have that sort of money to spend on his pastime, so a cheaper way of doing the job is preferable — but it must also produce boards of good quality. One of the best resists for hobby use (the method is not too expensive and can produce excellent quality boards) comes in the form of rub-down transfer sheets. All the shapes you need, ie holes, IC pads, transistor pads, straight and curved track, are available and a number of companies produce their own versions. Most electronics hobby shops will stock at least one variety. An outlay of about a fiver should get you all of the shapes you need to let you make a number of PCBs.

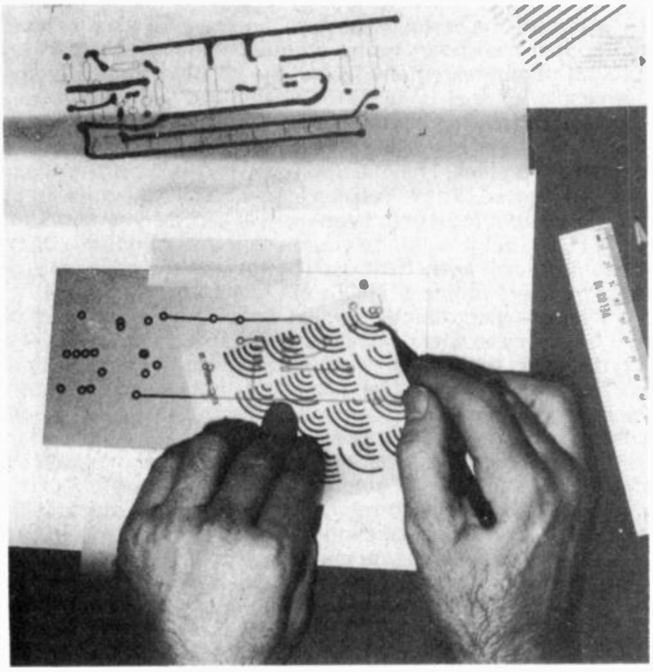
Putting the foil pattern on the copper board is easy:



1) Lay the pattern on the copper surface of the board and, with a sharp-pointed instrument (a scriber or the point of a pair of compasses), prick through the pattern in to the copper at every component hole location. The foil pattern can be your own design or one taken from HE.



2) At every prick-mark in the copper, rub down a transfer circular hole.



3) Following your foil pattern, interconnect the holes with transfer tracks until the resist on the copper has the same overall shape and connections as your foil pattern drawing. Be careful as you do this job, because any small cracks or breaks in the resist will mean that a corresponding crack or break will occur in the copper when the board is etched. If you make any mistakes at this stage, they can be removed with the corner of a small piece of sticky tape — but once you have etched the board your mistakes are permanent.

When you finish this task your board is ready to be etched.

Etching Your PCB

The etchant used to etch PCBs is not actually an acid — it's ferric chloride a horrible messy fluid — but it does its job well. Most local component stockists will sell it bagged as crystals or granules and you simply mix water with them to give an etchant solution.

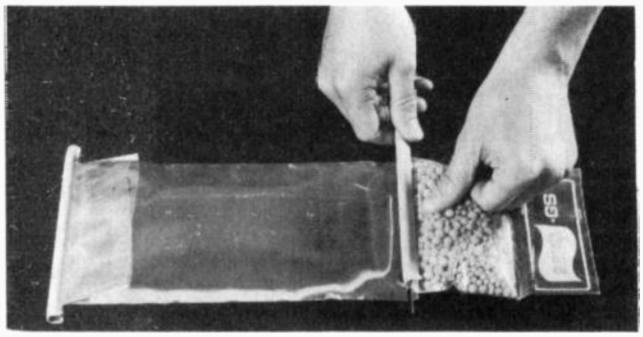
The etching process takes place more rapidly when the ferric chloride solution is warm and you can buy specially built containers or 'baths' to hold the ferric chloride. These baths may be fitted with heaters to maintain a high temperature, with agitators to keep the solution moving (vital to stop the build-up of copper oxide on the surface of the copper, which prevents further etching). They are, however (you guessed it!) expensive.

At the other end of the scale, a plastic photographic-type dish can be used as a bath to hold the ferric chloride during etching, but this method is fraught with hazards — ferric chloride is a *very* dangerous fluid and a strong solution of it will merrily eat its way through your clothes, the carpet, or even the stainless steel kitchen sink (try explaining *that* to the missus!).

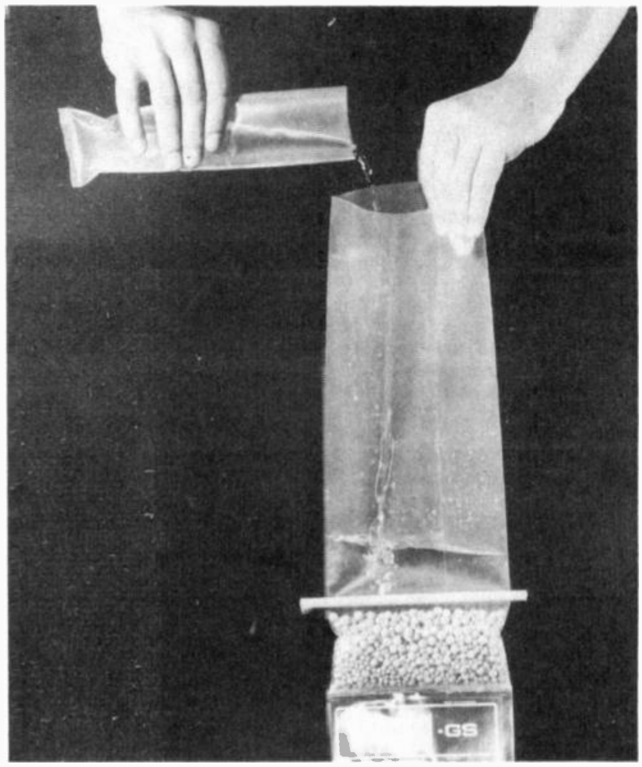
Until recently there was no real alternative to the these two methods but a new, low-cost, etching system seems to be the answer to the hobbyist's dreams. It's the subject of an HE Reader Offer, on page 51 and I think you'll agree that it offers excellent value for money.

The HE Reader Offer PCB Etching System is supplied in an expanded polystyrene box which is internally formed to hold the various bits before *and after* water has been added to the etchant granules. This polystyrene box, therefore, lets you store the system safely and tidily between use. Enough granules supplied to allow a number of PCBs to be etched. Most readers will find they use it only once or twice a month, so this way of storing it will be very convenient. All etching is done within a polythene bag and no mess is involved when making a PCB.

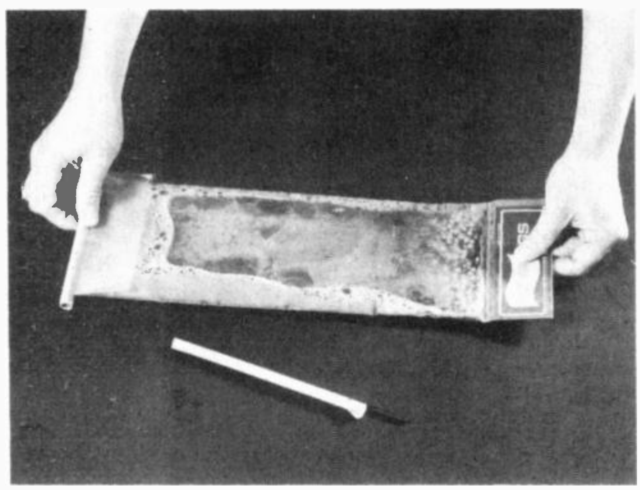
The way to use this system to etch a printed circuit board is illustrated in the following pictures. Start by unpacking the bag from its leak-proof box and making sure everything you need is to hand before commencing.



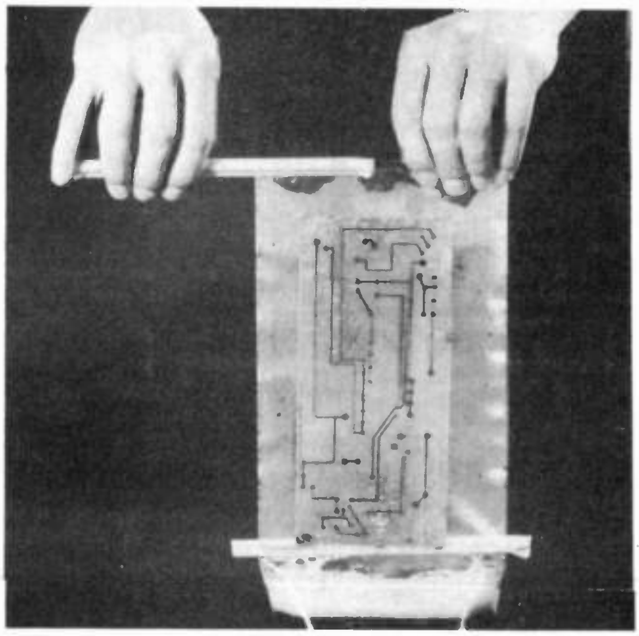
1). Holding the bag flat, make sure that the bottom clip is in place.



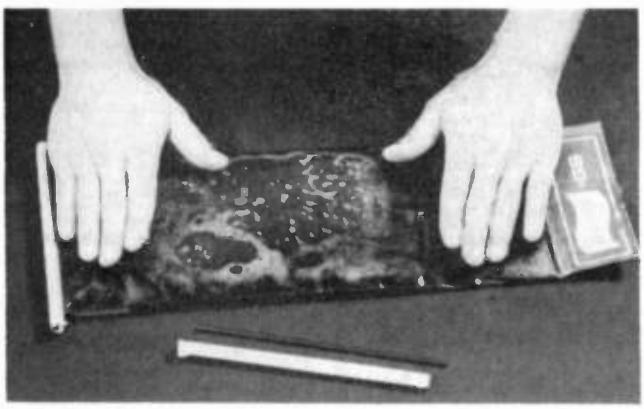
2). Remove the top clip and add 250 ml of warm water. If you have not got a measuring jug, use the polythene bag supplied. It will hold 250 ml when full to within an inch of the top.



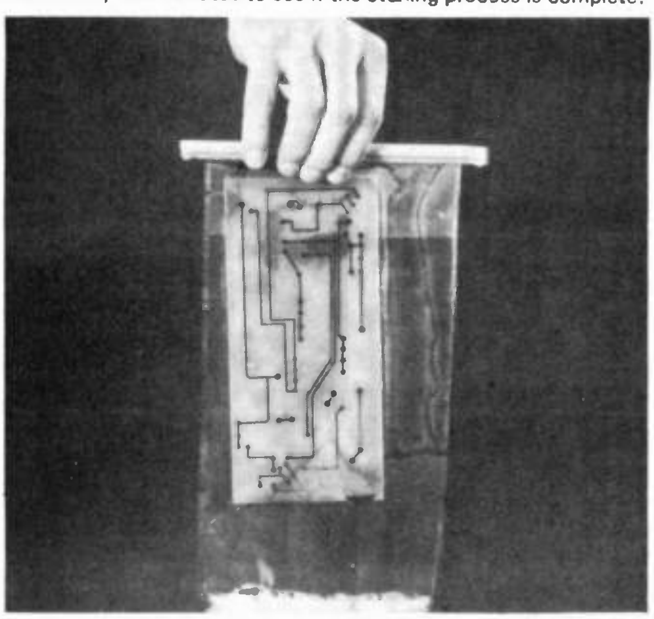
3) Re-seal the top of the bag. Remove the bottom clip, mixing the water and the granules. Rock the bag backwards and forwards to dissolve the granules.



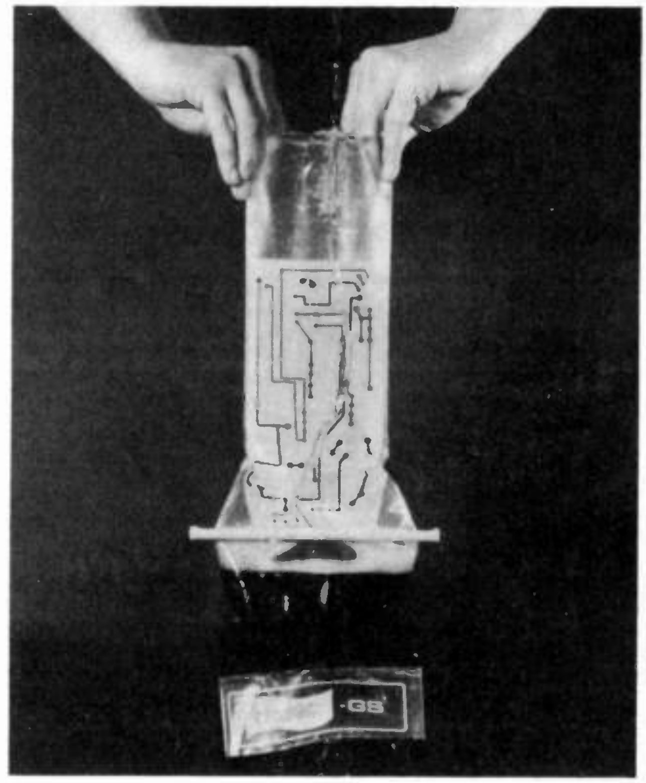
4) Seal the solution in the bottom of the bag. Unseal the top and insert the PCB then reseal the top.



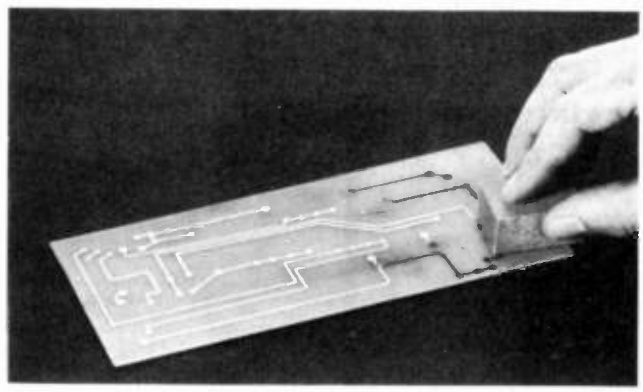
5) Release the bottom clip then, holding the bag flat, rock it so that the etching solution flows evenly across all parts of the board. Check every few minutes to see if the etching process is complete.



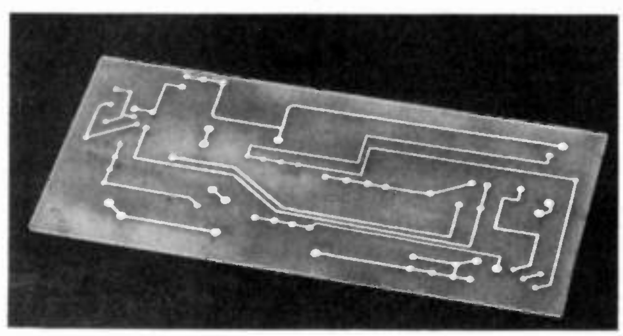
6) Hold the bag by the bottom and turn it upside-down; holding onto the PCB, turn the bag right way up and squeeze any remaining solution down into the bottom of the bag.



7) Seal off the solution in the bottom of the bag, then remove the top clip. Leaving the PCB inside the bag, rinse off with cold running water.



9) All that's left to do is to clean the etch-resist off the copper tracks and to drill the holes for the component leads. One of the many 12 V hand-held drills is suitable for the job, or a hand drill can be used if one of the powered variety is not available. The best sized drill bit is 1 mm.



10) The completed PCB! The board is now ready for the components to be inserted and soldered in place. Provided the PCB layout (and all the components) are correct, there is now very little that could — or should — go wrong!

HE

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COMPUTER BATTLESHIPS

Probably one of the most popular electronic games on the market. Unfortunately the design makes it impractical to test the PCB as a working model, although it may well function perfectly. Instead we have tested the sound chip, and sell the board for its component value: SN76477 sound IC; TMS1000 u processor; batt clips, R's, C's etc. Size 160 × 140mm. **Only £1.50**

Instruction book and circuit 30p extra

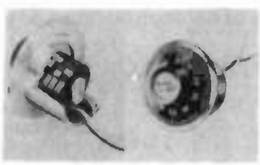
LOGIC 5

The object is to find the number held in the memory with as few entries as possible. PCB contains u-processor chip and 10 leds, and is linked to a membrane type keyboard. Overlay for keys and instruction provided. PCB sizes: 95 × 80 & 85 × 70mm. Supplied tested and working — PP3 required. **Only £2.50**

MICROVISION CARTRIDGES

These are a small PCB with a micro-processor chip, designed to plug in to the microvision console. Only snag is, we don't have any consoles!! However, they can be used as an oscillator with 4 different freq. outputs simply by connecting a battery and speaker. Tested and working (as an osc) with pin out data. PCB size 72 + × 60mm

ONLY 25p each!!



ELECTRO-DIAL

Electrical combination lock — for maximum security — pick proof. 1 million combinations!! Dial is turned to the right to one number, left to a second number, then right again to a third number. Only when this has been completed in the correct sequence will the electrical contacts close these can be used to operate a relay or solenoid. Overall dia. 65 × 60mm deep **Only £9.95**

DEVELOPMENT PACKS

These packs of brand new top quality components are designed to give the constructor a complete range so the right value is to hand whenever required. They also give a substantial saving over buying individual parts

K001. 50V ceramic plate capacitors, 5%, 10 of each value 22pF to 1,000pF, total 210. **£4.00.**

K002 Extended range 22pF to 0.1. Values over 1000pF are of a greater tolerance. 10 of each value 22 27 33 39 47 56 68 82 100 120 150 180 220 270 330 390 470 560 680 820 1000 1500 2200 3300 4700 6800 .01 .015 .022 .033 .047 .1. **PRICE: £7.00.**

K003 C280 or similar Polyester capacitors, 10 each of the following: .01, .015, .022, .033, .047, .068, .1, .15, .22, .33 and .47μF. **PRICE: £5.40.**

K004 Mylar capacitors. Small size, vertical mounting 100V. 10 each of the following: .001, .0012, .0015, .0018, .0022, .0027, .0033, .0039, .0047, .0056, .0068, .0082, .01. Total 130 capacitors. **PRICE: £4.70.**

K007 Electrolytic capacitors 25V working small physical size axial or radial leads. 10 each of the following: 1, 2.2, 4.7, 10, 22, 47, 100μF. Total 70 capacitors. **PRICE: £3.59.**

K008 Extended range, as above, also including 220, 470 and 1000uF all at 25V. Total of 100 capacitors. **PRICE: £6.35.**

K021 CR25 resistors or similar, miniature ¼ watt carbon film 5%, as used in nearly all projects. 10 of each value from 10 ohms to 1M, E12 series. Total 610 resistors. **PRICE: £5.95.**

K041 Zener diodes 400mW 5%. 10 of each of all the values from 2V7 to 36V. Total 280 zenners. **PRICE: £15.95.**

K051 LEDs – pack of 60, comprising 10 each red, green and yellow 3mm and 5mm, together with clips. **PRICE: £8.95.**

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200uF 350V, 100 + 100 + 50uF 300V can. 75 × 44mm dia. 40p; 10/£3; 100/£20
100uF 25V axial 100/£3.

1N4002 DIODES

Lowest ever price!! full spec by Motorola Pre formed leads for horiz mntg., 10mm pitch 100V 1A rating 100 **£1.75**; 500 **£7.50**, 1k **£14**, 5k **£65**

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We've just purchased another 5 million preformed resistors, and can make a similar offer to that made two years ago, **at the same price!!!** K523 1,000 mixed ¼ and ½W 5% carbon film resistors, preformed for PCB mntg. Enormous range of preferred values 1,000 for **£2.50**; 5,000 **£10**; 20k **£36**.

200 ELECTROLYTICS, £4

K524 Large variety of values/voltages, mostly cropped leads for PCB mntg. 1-1000uF, 10-63V. All new full spec. components, not chuck-outs!! 200 **£4**; 1,000 **£17.50**.

CHEAP CHIPS

76477 Sound IC	£1.25
2102A RAM 8 for	£3
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uA78MG + volt reg	£1.00
uA79MG — volt reg	£2.00

FILAMENT DISPLAYS

Z653 7 seg display 12.5mm high. Ideal for TTL operation, taking 5V 8mA per seg. Std 14 DIL package. Only **£1** each, 4 for **£3.00**. Data supplied.

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FNA5220 2 digit ½" 7-seg. display on PCB, CC. With data. **£1.50**

7-seg displays: FND360, 367, 501, all **50p**; 530, 847, 850, all **£1.50**.

Regs. TO3 case 7924 **120p**, 7885 **100p**, 7808 **100p**, 7912 **100p**, 78CB **230p**. Others on B/L 13

Op Amps: uA4136 **130p**; uA776 **145p**; uA777 **300p**; uA318 **245p**.

Isolators: FCD831, IL15, TIL118, all **60p**.

TIL311 Hexadecimal display with decoder, 0-9 and A-F. With data, **£3.50**.

COMPONENT PACKS

K503 150 wirewound resistors from 1W to 12W, with a good range of values **£1.75**

K505 20 assorted potentiometers, all types including single ganged, rotary and slider **£1.70**

K511 200 small value poly, mica, ceramic caps from a few pF to .02uF. Excellent variety **£1.20**

K514 100 silver mica caps from 5pF to a few thousand pF. Tolerances from 1% to 10% **£2**

K520 Switch Pack, 20 different, rocker, slide, rotary, toggle, push, micro, etc. Only **£2**.

K521 Heatshrink Pack, 5 different sizes each 200mm, **50p**

PANELS

Z521 Panel with 16236 (2N3442) on small heatsink, 2N2223 dual transistor, 2 BC108, diodes, caps, resistors, etc. **60p**

Z482 Potted Oscillator Module works from 1.20V, can be used as LED flasher (3V min.). Supplied with connection data, suitable R, C & LED **£1**

Z527 Reed relay panel – contains 2 × 6V reeds, 6 × 2S030 or 2S230, 6 × 400V rects + Rs **50p**

Z529 Pack of ex-computer panels containing 74 series ICs. Lots of different gates and complex logic. All ICs are marked with type no. or code for which an identification sheet is supplied. 20 ICs **£1**; 100 ICs **£4**.

A504 Black case 50 × 50 × 78mm with octal base. PCB inside has 24V reed relay, 200V 7A SCR, 4 × 5A 200V rects, etc. **60p**

RELAY/TRIAC PANEL

Z537 PCB 100 × 75mm containing a wealth of components:

2 × 12v DPCO min. relays, 2 × 47uf 16v tants, SC146E 10A 500v triac, C112d 8A 400v SCR, 555 timer, 10 × IN4001 diodes, 2N5061, 2 × 3mm leds 3 × 2N3704, also R's and C's.

Amazing value!! — if bought separately parts would cost around £8!! — Price for the panel just **£2.00**.

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A011 Compact audio amp intended for record player on panel 95 × 65mm including vol control and switch, complete with knobs. Apart from amp circuitry built around LM380N or TBA820M, there is a speed control circuit using 5 transistors. 9V operation, connection data supplied **ONLY £1.50.**

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Model No	Output power Watts rms	DISTORTION THD Typ at 1kHz	DISTORTION IMD 50Hz/7kHz 4:1	Supply voltage Typ/Max	Size mm	Wt gms	Price inc VAT	Price ex VAT
HY 30	15w/4-8Ω	0.015%	<0.006%	±18±20	76×68×40	240	£8.28	£7.29
HY 60	30w/4-8Ω	0.015%	<0.006%	±25±30	76×68×40	240	£9.58	£8.33
HY 120	60w/4-8Ω	0.01%	<0.006%	±35±40	120×78×40	410	£20.10	£17.48
HY 200	120w/4-8Ω	0.01%	<0.006%	±45±50	120×78×50	515	£24.39	£21.21
HY 400	240w/4Ω	0.01%	<0.006%	±45±50	120×78×100	1025	£36.60	£31.83

BIPOLAR Standard, without heatsinks

Model No	Output power Watts rms	DISTORTION THD Typ at 1kHz	DISTORTION IMD 50Hz/7kHz 4:1	Supply voltage Typ/Max	Size mm	Wt gms	Price inc VAT	Price ex VAT
HY 120P	60w/4-8Ω	0.01%	<0.006%	±35±40	120×26×40	215	£17.83	£15.50
HY 200P	120w/4-8Ω	0.01%	<0.006%	±45±50	120×26×40	215	£21.23	£18.46
HY 400P	240w/4Ω	0.01%	<0.006%	±45±50	120×26×70	375	£32.58	£28.33

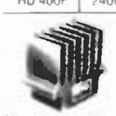
Protection: Load line, momentary short circuit (typically 10 sec). Slew rate 15V/μs. Rise time: 5μs. S/N ratio 100db. Frequency response (-3dB):15Hz-50kHz. Input sensitivity 500mV rms. Input impedance 100kΩ. Damping factor (8Ω/100Hz)>400.

HEAVY DUTY with heatsinks

Model No	Output power Watts rms	DISTORTION THD Typ at 1kHz	DISTORTION IMD 50Hz/7kHz 4:1	Supply voltage Typ/Max	Size mm	Wt gms	Price inc VAT	Price ex VAT
HD 120	60w/4-8Ω	0.01%	<0.006%	±35±40	120×78×50	515	£25.85	£22.48
HD 200	120w/4-8Ω	0.01%	<0.006%	±45±50	120×78×60	620	£31.49	£27.38
HD 400	240w/4Ω	0.01%	<0.006%	±45±50	120×78×100	1025	£44.42	£38.63

HEAVY DUTY without heatsinks

Model No	Output power Watts rms	DISTORTION THD Typ at 1kHz	DISTORTION IMD 50Hz/7kHz 4:1	Supply voltage Typ/Max	Size mm	Wt gms	Price inc VAT	Price ex VAT
HD 120P	60w/4-8Ω	0.01%	<0.006%	±35±40	120×26×50	265	£22.82	£19.84
HD 200P	120w/4-8Ω	0.01%	<0.006%	±45±50	120×26×50	265	£27.17	£23.63
HD 400P	240w/4Ω	0.01%	<0.006%	±45±50	120×26×70	375	£39.42	£34.28



Protection: Load line. PERMANENT SHORT CIRCUIT (ideal for disco/group use should evidence of short circuit not be immediately apparent). The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs as for standard types.

How to order Freepost: Use this coupon, or a separate sheet of paper, to order these products, or any products from other ILP Electronics advertisements. No stamp is needed if you address to Freepost. Cheques and postal orders must be crossed and payable to ILP Electronics Ltd: cash must be registered. C.O.D. — add £1 to total order value. Access and Barclaycard welcome. All UK orders sent post free within 7 days of receipt of order.

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UNIVERSAL RELAY DRIVER

Operating a relay to switch heavy current or mains voltages is a common application. This project permits a relay to be switched in a variety of ways, from a variety of inputs.

THIS VERSATILE relay driver unit is intended to be used with projects or devices not normally providing a switched relay output. In addition, power for external circuitry can be obtained from the board.

The unit has three groups of 'logic' inputs and a direct input. The relay itself is driven by two transistors, Q1 and Q2, and the direct input goes to the base of Q1 via a resistor (R7). Linking this input to the unit's 0 V rails — via a switch, a transistor which is turned on by a signal (open-collector logic) or a logic gate output — will operate the relay.

The logic circuitry on the board can be implemented by installing Link 1, which connects the output of the logic circuitry to the direct input. There are two 'logic high to operate' inputs (pins 1 and 2). A logic high level — ie a voltage level above about 2 V — on either of these inputs will operate the relay. There are also two 'logic low to operate' inputs (pins 7 and 8). Pulling either of these inputs below logic low — about 0V5 — will operate the relay. Note that these input pairs are ORed with diodes and can be linked so that one input inhibits the other. In addition there are two 'latch' inputs, pins 3 and 5. Pin 4 is the output of the latch circuitry and latch operation is implemented by linking this pin to one of the other inputs. All the logic inputs are high impedance and can be driven from CMOS circuitry.

The unit is powered from a 12 to 15 V AC source such as a battery or 5 VA transformer. Supply for IC1 (and perhaps any off-board circuitry) is obtained from a simple zener regulator circuit. This can be chosen to suit individual requirements. We used a BZX61C/8V2 zener to provide an 8V2 rail for IC1, and a 220 ohm, 1 W resistor for R5. You can use any convenient zener from 5V1 to 15 V — but no higher, and we recommend 1 W types run at around 50-60 mA current.

You will have to work out the value of R5 according to your choice of zener. For a 15 V zener, R5 could be 47 ohms, for a 5V1 zener, 270 ohms, or for a 12 V zener, say 100 ohms. There's plenty of latitude and these values are only given as a guide.

The logic circuitry (ie IC1) can be supplied from an off-board source if you wish. To do so, remove R5 and use a 15 V zener for ZD1 to prevent spikes on the external supply line causing damage to IC1. Note also that the logic levels on inputs 1, 2, 3 and 5 should also be no higher than 15 V.

The accompanying drawings illustrate how the unit is used in its four basic modes of operation.

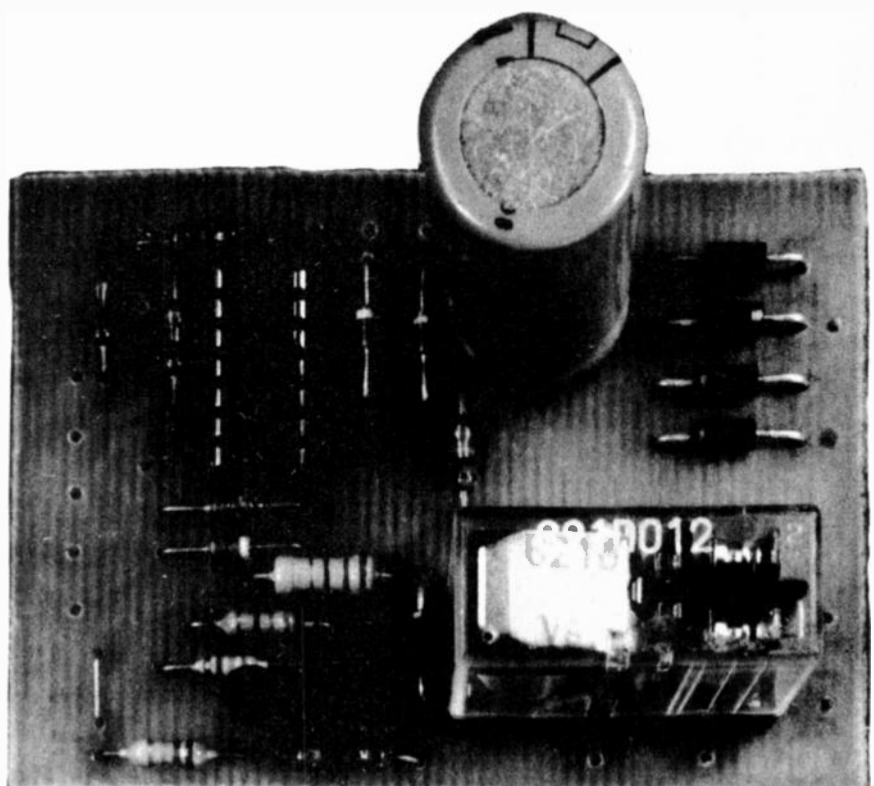
Construction

Construction is very straightforward. The components may be mounted in any order but you will probably find it easiest to leave the relay and C1 until last. Watch the polarity of all the diodes, the transistor and the IC. However, leave out Link 1 at this stage.

Once you've got it together and have checked everything, apply 12 V AC to the AC input and check various modes of operation as follows:

(1) Bridge the free end of R7 to ground. The relay should operate.
(2) Install Link 1, then bridge pin 7 to ground. The relay should operate. Likewise for pin 8.
(3) Bridge pin 1 to the cathode of the zener. The relay should operate. Likewise for pin 2.
(4) Connect pin 4 to pin 1 or 2. The relay may operate. Apply a pulse to pin 3 or 5 and see that it latches on. A pulse on the other input will drop it out again.

If all is well, you unit is ready for installation!



The relay driver board is simple, yet versatile. The external input/output pins are located around the edges of the board.

How It Works

The best place to start is right in the middle of the circuit — because that's the 'business' end!

Transistor Q2 has relay RLA 1 as its collector load. Diode D5 provides protection for Q2 when the coil current is cut off whenever Q2 is turned off. The base of Q2 is driven by the collector of Q1 via R8 and R9. Base bias for Q1 is obtained from the resistor network of R6 and R7. The 'free' end of R7 can be linked to on-board logic circuitry (IC1) or driven by an external source.

If the free end of R7 is connected to 0 V then base current will flow in Q1 which will turn on. This will turn on Q2 and the relay will operate. In fact, all that is required to turn Q1 on is to 'pull' the free end of R7 about 1 V below the positive supply rail to overcome the 0V6 base-emitter turn-on voltage of Q1.

Effectively, a 'low' level on the free end of R7 will operate the relay.

Two groups of logic circuitry built around IC1 are included to provide a variety of operating 'modes'. IC1 is a quad NOR gate package. One gate, IC1d, is arranged to provide a 'logic high to operate' mode. Two diodes connected as simple OR gate have their cathodes connected to pin 1 of IC1d. The output of another gate, IC1c, drives the other input, pin 2, of IC1d. IC1c has one input (pin 6) connected to 0 V, which is thus held at logic low. Pin 5 IC1c is held at logic high by R3 and thus its output, pin 4, will be low. As this drives pin 2 IC1d, its output (pin 3) will be high. With Link 1 fitted, Q1 will normally be off and the relay not operated.

When a high logic level is applied to either input pin 1 or 2, or both, the diode(s) will conduct driving pin 1 IC1d high. The output, pin 3, will go low and the relay will operate. The relay will remain operated only while the input remains high.

Two diodes (D6, D7) are connected as a simple OR gate with their anodes connected to pin 5 IC1c. A logic low on either input pin 7 or 8 ('logic low to operate') or both will pull pin 5 IC1c low and its output, pin 4, will go high. Pin 2 IC1d will go high and thus pin 3 IC1d will go low and the relay will operate. The relay will remain operated only while the input remains high.

The remaining two gates from IC1 are connected as a set-reset (SR) flip-flop. Pin 4 on the printed circuit board provides an output which may be coupled to the other inputs. Assume the SR flip output is initially low. A pulse applied to input pin 5 will cause pin 4 (pins 9, 11 or IC1a, b) to 'latch' high. A pulse then applied to the opposite input pin will cause the output to go low again and remain low.

This part of the circuit can be used as a 'switch debouncer' as illustrated.

Power is derived from an off-board 9 V AC or 12 V AC source. This drives a bridge rectifier, diodes D1 to D4, smoothing being provided by C1. A zener diode, ZD1, is used to provide a regulated supply to the logic circuitry (IC1).

Buylines

There should be no problems with any of the components used in this project — they are all easy-to-obtain types. The PCB-mounting relay is type RL111 from Watford Electronics, whose address can be found elsewhere in this issue.

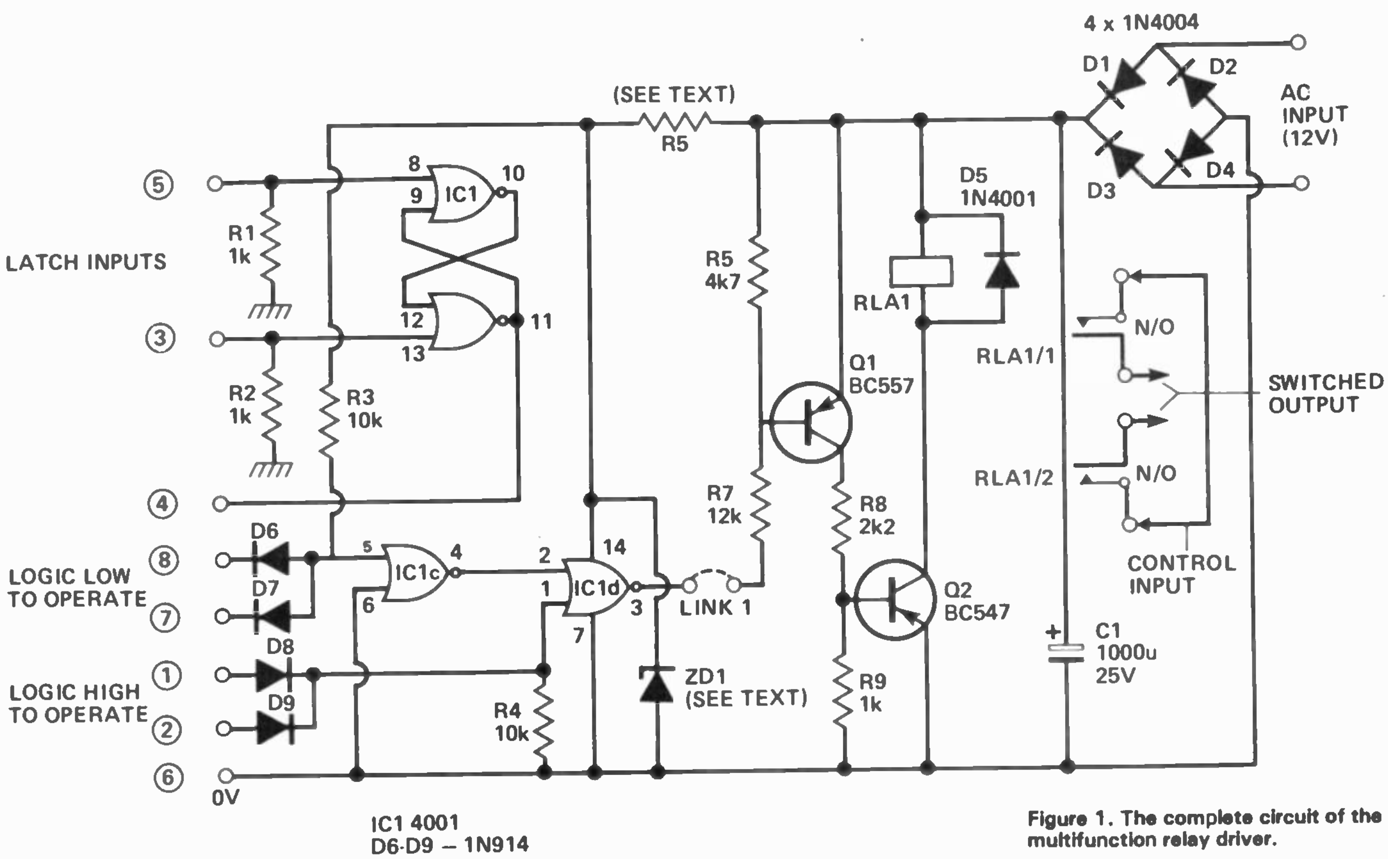
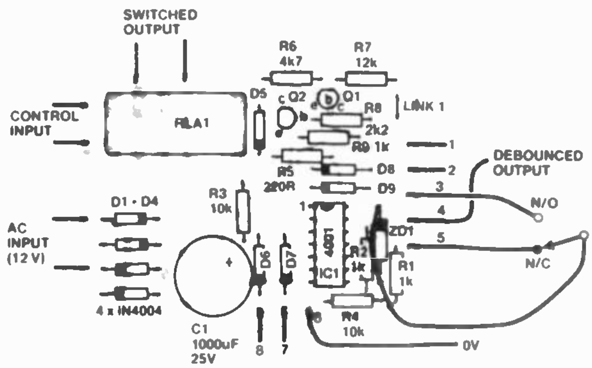
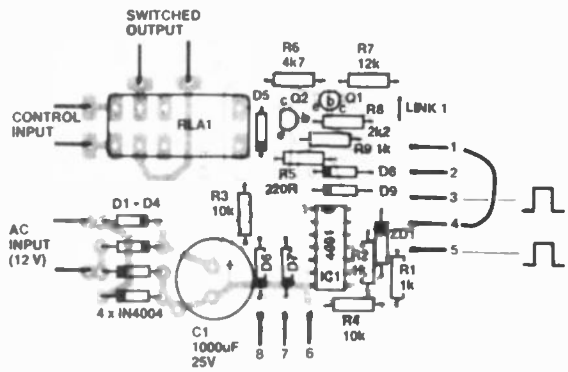


Figure 1. The complete circuit of the multifunction relay driver.



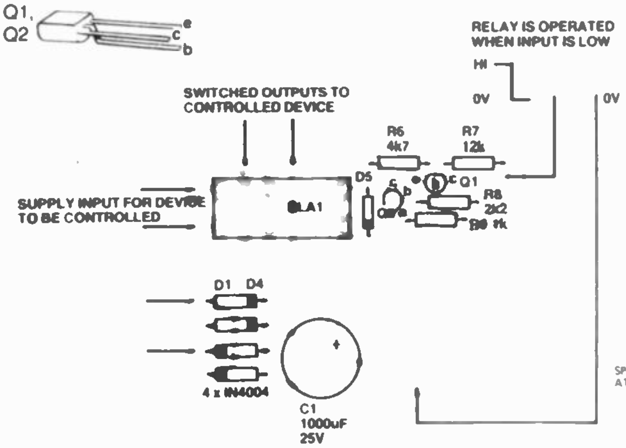
LATCH OPERATION

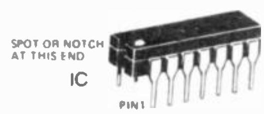
Pin 4, the output of the set-reset (SR) flip-flop, must be linked to either pin 1 or pin 2, or pins 7 or 8. A positive-going pulse on pin 3 or pin 5 will cause the relay to latch. A positive-going pulse on the opposite latch input will then cause the relay to unlatch.

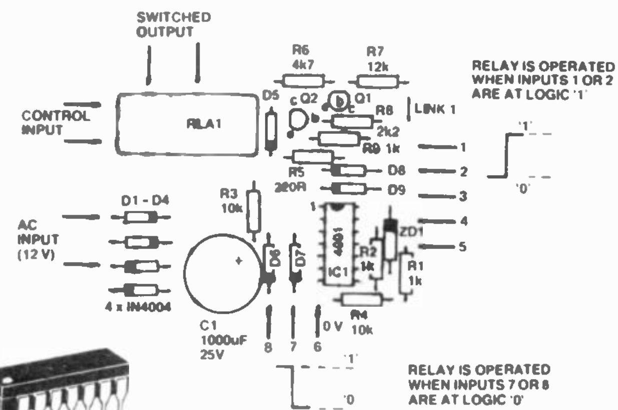


SWITCH DEBOUNCING

The SR flip-flop (IC1a and b) is not electrically connected to the rest of the circuit and may be used in external circuitry — for example, as a switch debouncing circuit.







DIRECT INPUT

The relay will operate when the input is low (ie 0 V) or 'pulled' about 1 V lower than the positive supply rail. Only those components shown are necessary for this mode of operation.

LOW OR HIGH TO OPERATE

The relay will be operated when pins 1 or 2 are held at logic high. To operate the relay from a logic low, pins 7 or 8 must be held at logic low. The inputs are ORed so that up to two input signals can be employed to operate the relay in each mode.

Parts List

RESISTORS (all ½ W, 5% unless noted)

R1,2,9	1k0
R3,4	10k
R5	220R, 1W (see text)
R6	4k7
R7	12k
R8	2k2

CAPACITORS

C1	1000 u, 25 V electrolytic (PCB mounting)

SEMICONDUCTORS

IC1	4001B
Q1	BC557
Q2	BC547
D1-D5	1N4001, 1N4002 etc
D6-D9	1N914, 1N4148 etc
ZD1	400 mW or 1 W zener, see text

MISCELLANEOUS

PCB; RLA1 — relay (type RL111).

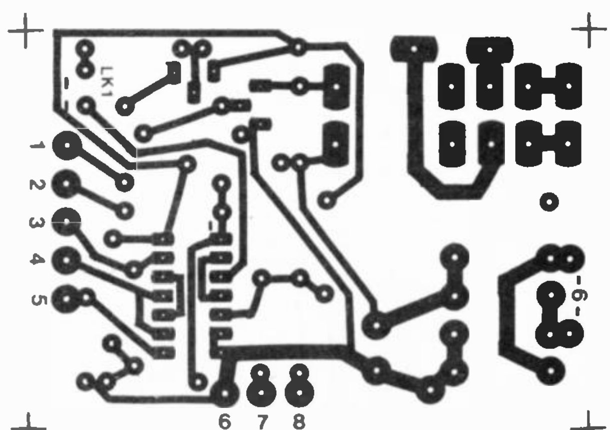
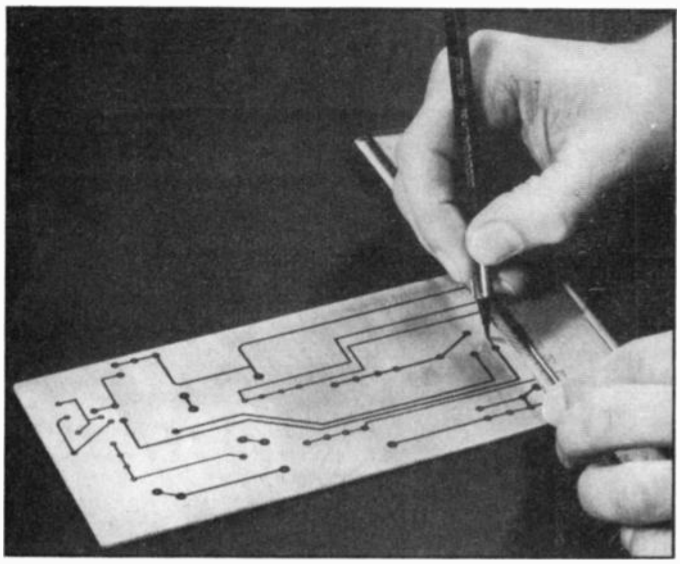
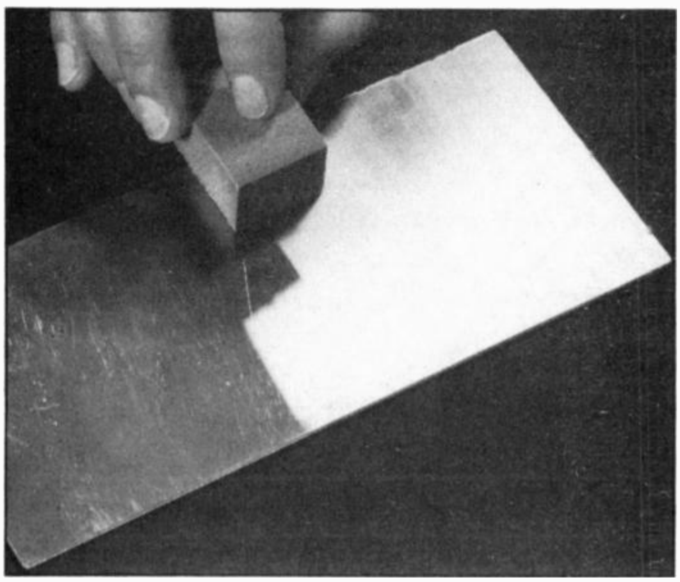


Figure 2. Bottom view of the PCB - make it yourself (see page 11).

HE

Seno GS PCB Etching Kit Etch Resist Pen Polyfix cleaning block Two Single Sided boards £9.50





PCB Etching Kit

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Your Letters

The Editor answers a selection of your letters

Printed Circuit Boards

Dear Sir,
Can you help, please? You sometimes state that matrix board (strip board) should not be used and that we must use PCBs. Why? Is this due to stray capacitance?

I built your Kitchen Timer, albeit modified so that the output, instead of going straight to the buzzer, goes through a circuit repeating the alarm at one minute intervals. Simple enough. It works, except for the calibration. One can calibrate out of the steel case but as soon as it is assembled in the case the calibration goes awry. Is this also due to stray capacitance, due to either the veroboard or the metal case? I would appreciate an explaination.

In any case I would like to make PCBs but have read articles for and against the standard method. I would prefer the photographic method for accuracy and perhaps time. I presume there is no method for doing the reverse, ie depositing a conductor in the appropriate place rather than etching the copper away.

Once again, your help would be appreciated.
E. Strang,
Krugersdorp, South Africa.

A very timely letter, this. The main reason for using PCBs is that they are neater, safer and allow less probability for error — always assuming that the circuit and the foil pattern itself is correct. And they do minimise stray capacitance which can be critical, particularly with circuits operating at high frequencies. I can see no obvious reason why the Kitchen Timer is behaving as you describe, but the effect does seem to be due to stray capacitance and putting the ciruit onto a PCB would certainly help. More simply, you should ensure that all the wiring is neat and external leads kept as short as practicable.

You will note that we are definitely FOR printed circuit boards and the article commencing on page 11 describes, step by step, one procerdure for making PCBs. It is not a photographic method but, if proper care is taken, it will produce virtually the same quality result.

Finally, there are methods for depositing metal in "appropriate places" but they are feasible only in industrial applications. In fact, transistors and ICs are made by a combination of etching and depositing different semiconductors and metals.

Problem Pages

Dear Sir,
I have been buying Hobby Electronics for a number of months. I know that, on occasion, gremlins get into circuits in the magazine. The gremlins have now migrated to the publishing mac hine. On obtaining my copy of December '81 HE recently I was surprised to find that what should have been page 3 was, in fact, page 15. Continuing, I reached page 30 and on turning to page 31 I found I was back at 15! This time I managed to reach page 62 without mishap, only to find that page 63 was actually page 47. I had double vision without touching a drop!
R. Dunlop,
Blairmore, Argyll.

We apologise to our readers who struck these somewhat odd copies. The gremlins had (have?) migrated to our printers, causing considerable amazement to readers scattered throughout the country. Hopefully these annoying beasties have now been exorcised.

PCB Prints

Dear Sir,
Such a build-up to your Guitar Graphic Equaliser which, I am sure is a well designed project. But, with a capital 'B', what happened to the PCB pattern? Your 'underground map of printed circuit boards' appears to be of the wrong area!
G. Lloyd,
Wolverhampton.

Wherever and whenever possible, we publish the PCB foil pattern for projects in Hobby Electronics. Unfortunately, three of the projcets in the December issue — the Equaliser, the Doorchime and the Drum Synthesizer, all highly popular projects, too — were designed for us by contributors who wished to retain the copyright on the PCB. For this reason we were unable to publish them. In general, the un-published PCB is the exception, certainly not the rule.

Errata and Back Numbers

Dear Sir,
Firstly, a question. In the January '82 isue of Hobby Electronics you describe the construction of a NiCad battery charger. In the circuit diagram on page 27 I noticed that the collector of transistor Q1 is left un-connected. If, as explained in the text, Q1 and Q2 form a Darlingtopn pair, shouldn't the collectors of these two transistors be connected?

Secondly, a request. Some time ago I sent two separate cheques to your back issues department to cover the cost of a January '81 and a March '81. I've received the January issue but not the other. Would you check this for me, please?

Finally, a comment. I've been teaching myself electronics for about six months. During that time HE has provided a great deal of interesting and instructive reading. For me, HE is much more comprehensible than other magazines on the market.
R. Berrisford,
Thorpe, Derbyshire.

Working backwards through Mr. Berrrisfords comments and queries, it is first of all gratifying that he chooses exactly those words we like to use for Hobby Electronics. We try to please — but also to inform — and we work very hard to ensure that we are 'comprehensible'.

The matter of the missing issue has been taken up with the Reader Services department and an answer will be forwarded in due course. In principle, back numbers are available for all previous issues of HE but in practice certain popular issues have 'sold out' and can no longer be obtained, even by the editorial staff.

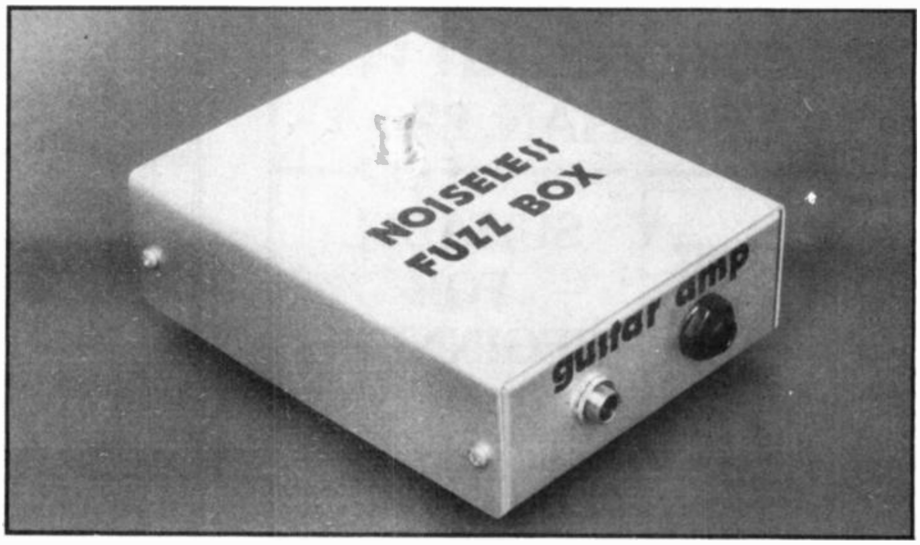
Then there's the gremlins (again) in the project. We're sure you know the line about "The best laid plans . . . ". As you say, the collectors of Q1 and Q2 should be connected. Try as we might to eradicate errors they still manage to creep in, like mice. Here's some more from the January '82 issue.

In the circuit of the Volume Expander (page 55) the unmarked transistor is, of course, Q2, the BF244B FET.

In the component layout of the Intruder Confuser (Figure 2, page 39) IC1 is shown up-side down. The notch dhould appear at the top, ie pin 1 is at the top left.

NOISELESS FUZZBOX

No buzz, just fuzz!



THERE HAS BEEN no shortage of FuzzBox designs over the past few years and while most of them gave a good fuzz effect, many unfortunately also made quite good noise generators as well! The increase in noise has been due tothe way in which the fuzz effect is produced; the two most common methods used are a high gain amplifier driving a clipping circuit (which generates the distortion and causes the effect), or a high gain amplifier with a built-in clipping circuit. The fuzz circuit itself is often followed by an attenuator which reduces the output to a level comparable to that produced by the guitar pick-up. This will also reduce the noise output of the unit proportionally, but there will still be a significant degradation in the overall signal-to-noise ratio of the system because the noise is actually being produced by the high gain amplifier.

A simple way of improving the *apparent* signal-to-noise ratio in situations such as this is to use a noise gate; a circuit that enables a signal to pass normally if it is above a certain level, but provides a fairly high level of attenuation (usually around 20 to 40 dB) if the signal is below the threshold level or is absent altogether. This system relies on the fact that when a reasonably strong signal is present it masks the noise. When such a signal is not present the noise gate provides attenuation which reduces the noise to an unnoticeable level. Thus the signal-to-noise ratio is apparently increased, although the *true* signal-to-noise ratio remains unaltered.

This fuzz unit has a form of noise gate action built in so that it does not give any significant increase in the apparent signal-to-noise ratio. It produces conventional clipping-type fuzz, is battery powered and connects between the guitar and the amplifier in the usual way. A foot-operated switch enables the fuzz effect to be switched out if required.

Construction

We used an aluminium case measuring about 133 x 102 x 38 mm to house this project, but any plastic or metal case having similar dimensions should be OK. The two sockets are fitted at one end of the case and SW2 is mounted on the lid towards the other end. As SW2 is foot-operated switch it is obviously a good idea to use a reasonably strong case, but it is likely that any ready-made plasic or metal case of the appropriate size will be more than tough enough. Otherwise, tread carefully!

Fit the small components on a 0.1" matrix stripboard having 36 holes by 15 copper strips using the component layout (and wiring) shown in **Figure 2.** Make the breaks in the copper strips, drill the two 6BA clearance mounting holes using a 3.2 mm diameter drill and then solder the components and link wires into place.

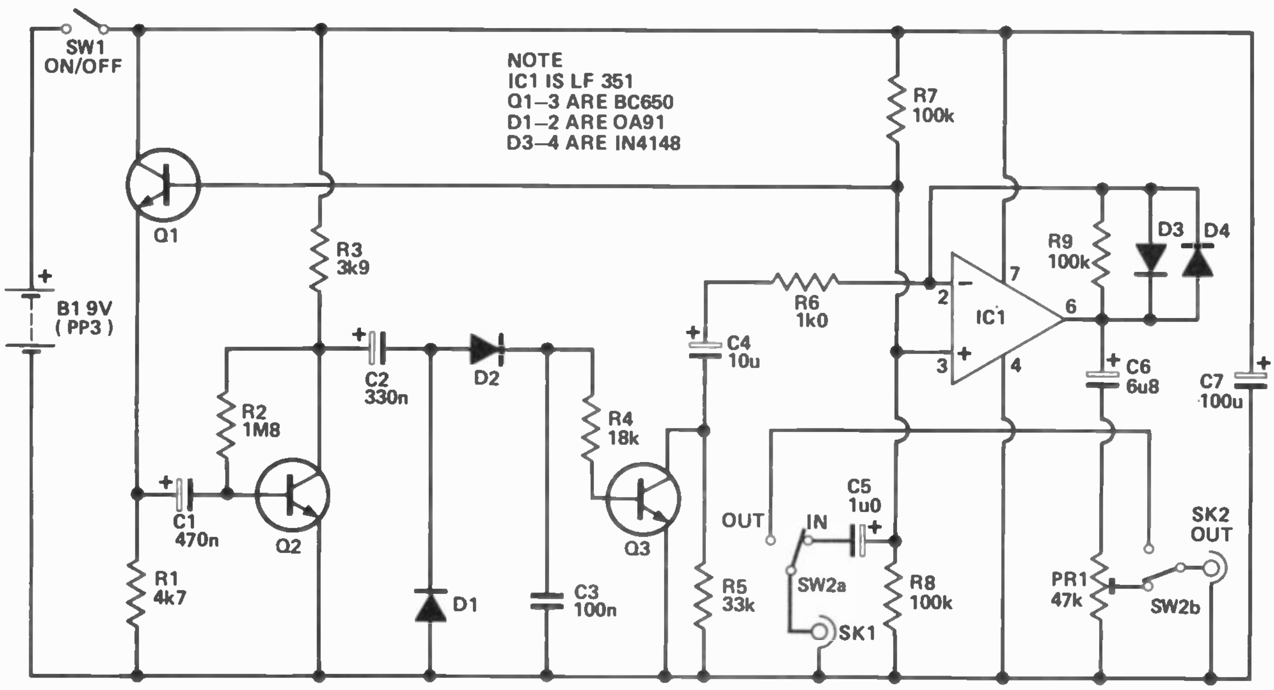


Figure 1. The noiseless circuit.

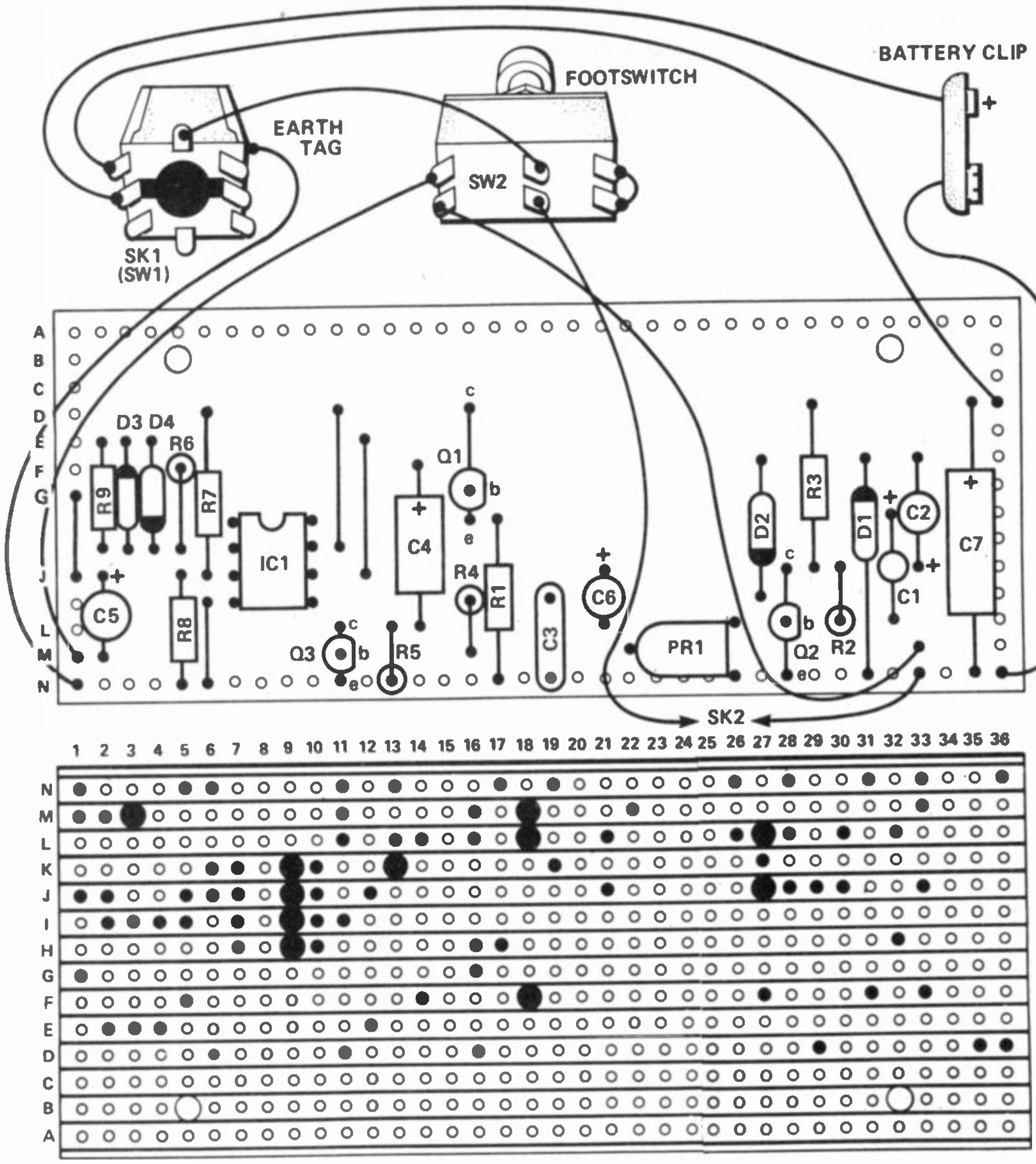


Figure 2. Component overlay and bottom view of stripboard.

Bolt the finished board to the base panel of the case between the sockets and SW2, using spacers to keep the underside of the board clear of the case, if it is metal. Of course, the point-to-point wiring must be finished before finally fitting the component panel in place. SK1 has double-pole, double throw (DPDT) contacts but these are used as an single-pole, single throw (SPST) switch in this circuit, with four of the switch tags left unused. If a separate on/off switch is preferred, there is ample space for this to be fitted alongside SK1 and SK2; SK1 can then be a straightforward ¼" jack socket.

In use, the unit is simply connected between the guitar and the amplifier using screened jack leads. Assuming a switched socket is used for SK1, the unit will automatically be switched on when the guitar is plugged in, and switched off again when it is unplugged — so don't forget to unplug it! PR1 is adjusted, by trial and error, to a setting that gives no significant change in volume when SW2 is used to switch the unit in and out of the signal path.

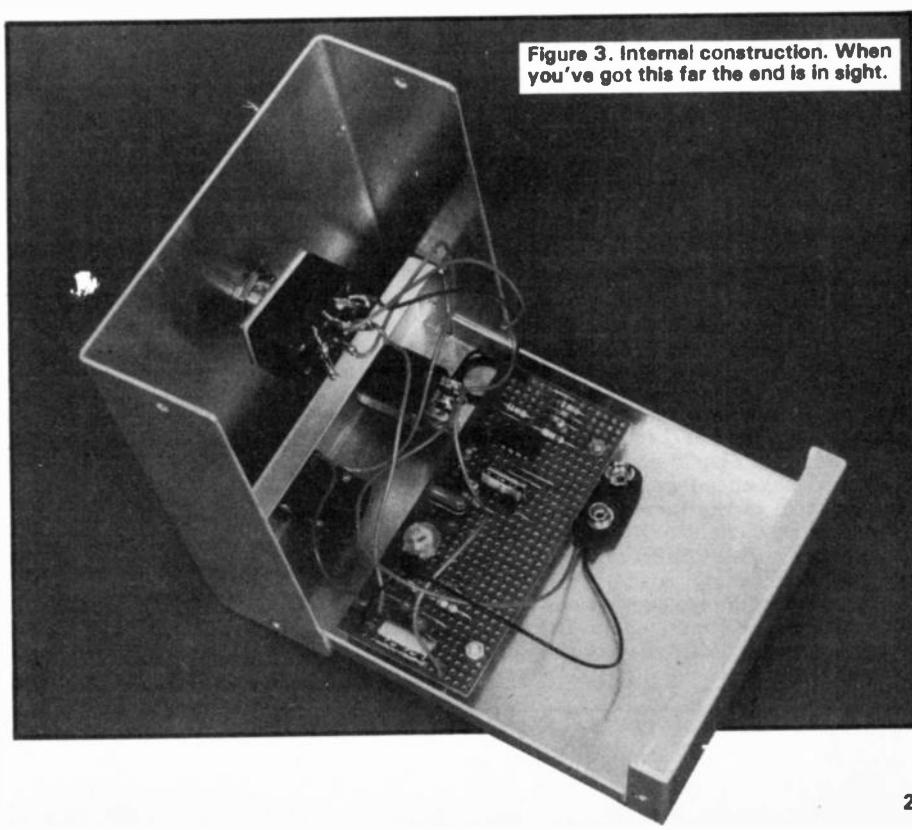


Figure 3. Internal construction. When you've got this far the end is in sight.

How It Works

The input signal is fed to the output via a high gain amplifier which clips the signal to give the familiar distortion of the fuzz effect. The output signal virtually a square wave.To give the circuit a low noise level in the absence of a signal, the gain of the amplifier is normally quite low and is only switched to a high level when a suitable input signal is present.This is achieved by taking some of the input signal to another high gain amplifier, rectifying and smoothing the output to give a DC signal and then using this signal to control a switching transistor in the negative feedback circuit of the clipping amplifier. With no input present, there is no DC signal produced, the switching transistor is turned off and the clipping amplifier has a low gain (and so a low noise output). With an input signal applied to the unit, a DC signal is produced and switches on the transistor. The negative feedback of the clipping amplifier is thus reduced and its gain is boosted by a factor of more than 20. This produces clipping and although the noise level is greatly increased, it is not apparent as the noise is masked by the guitar signal.

The full circuit diagram of the fuzz unit shows that it is basically a conventional op-amp clipping circuit based on IC1. A low noise BIFET op-amp is used so that the quiescent and operational noise levels of the unit are kept as low as possible.

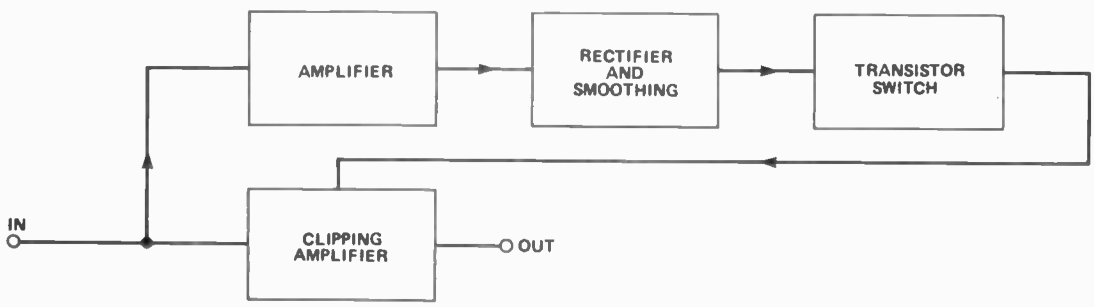
Normally IC1 has a voltage gain of about four and the gain is set at this level by the negative feedback network which consists of R5, R6 and R9. The voltage gain is actually equal to the sum of these resistances divided by the resistance of R5 and R6. If Q3 is switched on, its collector-emitter impedance becomes very low and effectively short-circuits R5. The gain of the circuit then becomes equal to R6 plus R9 divided by R6, or just over 100 (40 dB), with the specified values.

At this higher gain the output from any normal guitar pick-up will be sufficient to produce an output voltage swing of at least ± 0V6 from IC1; this causes D3 to conduct on positive peaks and D4 to conduct on negative peaks. When either D3 or D4, are conducting, then, they shunt R9 and effectively reduces the value of the feedback resistances. In fact the reduction in gain produced by the two diodes is so great that the output does not change significantly while one or the other of them is biased into conduction, giving the required clipping action. C6 couples the output of IC1 to a simple variable attenuator using PR1 as a volume control. With many pick-ups,the output from IC1 will be much higher than the direct output of the pick-up and PR1 is adjusted to reduce amplified output to match the 'straight' guitar signal. SW2 is a foot-operated switch which can be used to bypass the unit when the fuzz effect is not required and, provided PR1 is adjusted properly, there will be no obvious change in signal level when SW2 is operated.

R7 and R8 are used to bias the non-inverting input of IC1 and, as this device is used in the non-inverting mode, the input signal is coupled to this input by C5. R7 and R8 are also used to bias Q1, which is used as an emitter follower buffer stage. The output of Q1 is coupled by C1 to the input of a high gain common emitter amplifier, Q2, and this stage provides about 40 dB of gain. With a reasonably strong input signal, Q2 supplies a large output signal which is rectified and smoothed by D1, D2, and C3. The resultant positive DC bias is used to drive Q3 by way of R4.

The switching circuit has a fast attack time so that Q3 is switched on almost immediately when an input signal is present. The decay time is also quite short, so that if the input signal suddenly ceases, the noise level also drops. If the input signals fades out quite slowly, then Q3 will switch off quite slowly too; a desirable feature as it masks the action of the noise gate circuit.

SW1 is the on/off switch and is actually a make contact on SK1 so that the unit is automatically switched on when the guitar is plugged into the input socket. A separate on/off switch can be used if preferred. The current consumption of the circuit is about 4.5 mA.



Buylines

The case we used is a Maplin type AB10, but there are many suitable alternatives. The DPDT foot-switch is available from Maplin and the DPDT switched jack socket can be obtained from Maplin or Watford Electronics. There should be no difficulty in obtaining a suitable BIFET op-amp for the IC1 position — a TL071CP or TL081CP are suitable alternatives for the LF351 we used. The other components are all easy-to-obtain types.

Parts List

RESISTORS (ALL ¼ W 5%)

R1	4k7
R2	1M8
R3	3k9
R4	18k
R5	33k
R6	1k0
R7,8,9	100k

POTENTIOMETER

PR1	47k minature horizontal preset

CAPACITORS

C1	470n 35V tantalum bead
C2	330n 35V tantalum bead
C3	100n polyester (C280)
C4	10u 25 V axial electrolytic
C5	1u0 35V tantalum bead
C6	6u8 15V tantalum bead
C7	100u 10V axial electrolytic

SEMICONDUCTORS

IC1	LF351
Q1,2,3	BC650
D1,2	OA91
D3,4	1N4148

MISCELLANEOUS

SK1	Standard ¼" jack socket with DPDT contacts (SW1)
SK2	Standard ¼" jack socket
SW2	DPDT heavy duty footswitch

Case measuring about 133 x 102 x 38 mm, PP3 size battery and connector to suit, 0.1" matrix stripboard, wire, solder, etc.

HE

Clever Dick

Accept no substitute!

The heading this month is another of our Editor's attempts at wit — that's what he calls it and who am I to argue? It was inspired (if that's the word) by a number of letters, this month, offering alternative designs for the Substitution box project from the November '81 issue.

Dear CD,
I was looking at the substitution boxes in the November issue. I saw that the heart of the project — the resistors — were only 2p each but the switches were 65p each, so I have re-designed the circuit. Mine has 96 resistances instead of 24 and it doesn't need a changeover switch.
If you need a capacitor substitution box you only need one rotary switch and one changeover switch.
Yours Sincerely,
Nicholas Bradley,
Havant, Hants.

PS Can I have a binder, please?

My advice, Nicholas, is to stick to electronics, and leave economics well alone!

Offers of assistance abound this month (enough, stop, cease and desist etcetera), and this gentleman then had to nerve to ask for help!

Dear CD,
. . . Now if you could help me, where can I get thyristor C103 used in the Reaction Tester (September '81)? Also, could you give me a supplier for Tescus Instruments TO3 transistor R1039? It comes from the line sequesncer of a television.
I. Scholey,
Edenbridge, Kent.

The first question is easy; try RS Components. The second is more difficult — sounds more like a supermarket than a transistor manufacturer — but I think you mean Texas Instruments, don't you? In either case, I can't help you; I have no record of a TI transistor with that number. Very often the parts used in commercial equipment are specially made and have non-standard designations and this is why I am usually unable to help with enquiries relating to commercial equipment!
I do like to help, you know, but sometimes you just have to help yourselves, if you see what I mean (no, I **don't** mean the binders)...

Dear CD
As part of my 'O' level technology project I am building your Six Watt Siren (March 1980), but the photograph does not make the component layout very clear. Could you please send me a diagram?
I've been reading HE since November 1978 so how about a binder to put by HEs in, or even my technology project?
K. McDermott,
Colchester, Essex.

It wasn't my project, I assure you — I had nothing to do with it, nothing — but you're quite right; it's not very clear, is it?
However, here is a letter followed by a genuine helpful reply; keep it and treasure it forever.

Dear Clever Dick,
I have a problem that you may be able to solve for me. I have been given a new car stereo radio/cassette. The instructions clearly say 'negative ground only' but I have an old car and its electrical system is positive ground. Is there any way I can install the new hifi in my old car? I would be grateful for any assistance you could offer.
A.M. Lawrence,
Chessington, Surrey.

Trade in your old car? If that's not practical (it isn't? Oh!) then you must be sure to insulate the chasis of the hifi from the car body. A piece of wood is as good as anything else; fix the wood to the car and the stereo to the wood, then connect the power leads normally — that is, negative to negative, positive to positive (the car chassis, in your case). Happy motoring!

Yes, CD administers assistance with a smile — and those ingrates who call it a smug sneer have written themselves permanently off the free binder list.

Dear Clever Dick,
I would appreciaste it if you could help me. I have not been able to obtain a U267B bargraph driver IC (LED VU Meter, November '81). Would I be able to order it from Britain?
Please could you send a binder to a regular reader of your fantastic magazine in South Africa?
A. Visagie,
Bloemfontein, South Africa.

Would you, could you? Of course. According to the Buyline for that project, the U267B is supplied by Ambit International. Their UK address is 200 North Service Road, Brentwood, Essex CM14 4SG, but if they really are International you might find them in South Africa!

Old HEs never die, it seems — they just disappear!

Dear CD,
Looking through my copies of HE the other day, I found that I have missed some of the earlier issues. If you could publish my letter, any fellow readers who have any of the issues, and do not want them, could write to you for my address. I would be so grateful as not to ask for a binder to put them in. The following are the issues that I need: November and December, 1978; January and November, 1979. Naturally, I would be happy to pay for them.
I. Spearman,
Ongar, Essex

Now before anyone gets bright ideas about cashing in their precious back-issues, this is not some kind of lonely hearts club for lost copies! However, I could, if you wish, publish your full address so that anyone with spare copies can contact you directly. Over to you, Mr. Spearman.

ANDREW MAWSON, ARE YOU THERE, ANDREW MAWSON?
Our super-efficient filing system has managed to 'eat' your address. Your binder awaits you.

Here we have a letter from a worried man — or perhaps the rest of us should be worried???

Dear CD,
When are you going to publish a circuit for a pocket radiation monitor? In the June issue you said you would — or did I blink and miss it? The world is waiting — what say you? Any new game projects coming up soon, please?
Keith Williams,
Basingstoke, Hants.
PS Great mag, keep it up.
PPS How's about a binder?

Did I say that . . . well, so I did. Don't know what happened to it, but I'll investigate, how's that? Why do you want a radiation monitor, anyway? Are you planning to start World War Three?

No brilliant ideas for games projects at the moment — maybe you'd like to suggest one or two? That's the cheapest grovel I've seen in ages, so the answer to your last question is . . . you guessed it.

Now here's a name that sounds familiar . . . if only I could remember . . .

Dear Clever Dick,
If you look at page 32
You will notice something new.
On page 50 there are ads,
Not a charger for nicads.
If this charger then you needYou had better now take heed.
It is on page 25,
That's where battery freaks get there kicks.
Now I've written to you in rhyme,
I think that it is about time
That you could get a bit kinder
And send me a Hobby Electronics binder.
Yours Sincerely,
Nicholas Bradley,
Havant, Hants.

Polite, isn't he? Not much of a poet, but polite with it, though.
It appears that Nicholas, and many others throughout the country, has been the victim of an error by our printers who, moving in ways more mysterious than ever before, managed to do strange and wondrous things with the January issue.

Persistance is its own reward, Nicholas, but you can have a binder as well.

Sinclair ZX81 Personal Comp[u]
the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

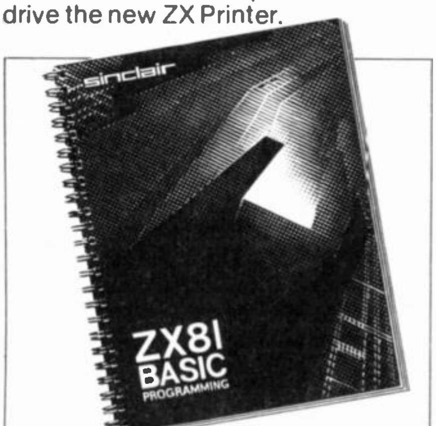
In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability
With the ZX81, it's still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, *and* to drive the new ZX Printer.



New BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs.

Kit: £49.95

Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

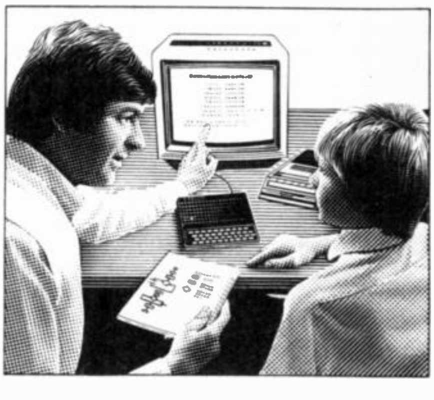
New, improved specification

- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer.
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Built: £69.95

Kit or built – it's up to you!
You'll be surprised how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.



uter-

Available now- the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alpha-numerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

16K-byte RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

With the RAM pack, you can also run some of the more sophisticated ZX Software – the Business & Household management systems for example.

How to order your ZX81

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST, Camberley, Surrey, GU15 3BR. **Order**

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
	Sinclair ZX Printer.	27	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

☐ Please tick if you require a VAT receipt TOTAL £

*I enclose a cheque/postal order payable to Sinclair Research Ltd. for £

*Please charge to my Access/Barclaycard/Trustcard account no.

*Please delete/complete as applicable

Please print

Name: Mr/Mrs/Miss

Address:

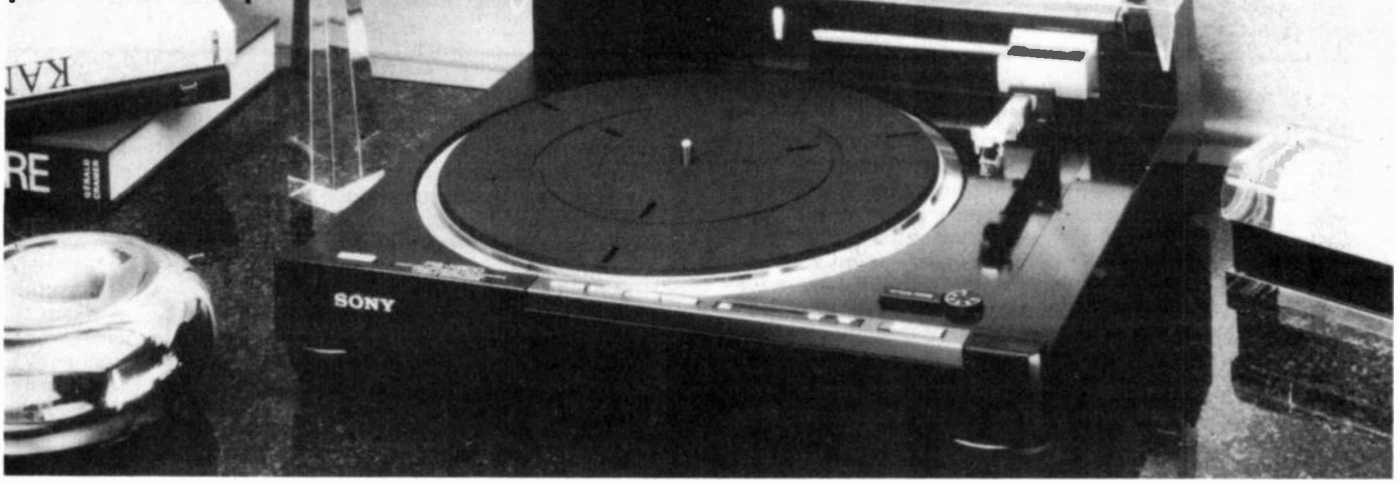
FREEPOST – no stamp needed. Offer applies to UK only. HEL 02

sinclair ZX81

6 Kings Parade, Cambridge, Cambs., CB2 1SN. Tel: (0276) 66104 & 21282.

SCALING the Hi-Fi HEIGHTS
Part 2: Record Decks

LAST MONTH WE chose the amplifier that will form the heart of our proposed system and went through the specs necessary to make that choice a logical one. This month we move on to the record player for the system and consider what factors are important to its operation.



FROM A SYSTEM POINT OF VIEW the record source and the amplifier must be chosen to compliment each other electrically. The player has to provide the correct level of signal, from the cartridge, to match the amplifier input and it must have the correct balance to suit your tastes and produce a smooth overall result from the system as a whole.

Follow the guidelines and keep in mind possible upgrades; changing the cartridge is often the first of these. Make sure, therefore, that the arm will accommodate any future ambitions you may harbour. If you're quite sure that you have none, an integrated player (combining turntable and arm) will probably suffice, but for those with aspirations to higher-fi, separates are the most economical course in the long run.

The basic aim of a record playing system is identical whether it is an integrated arm/cartridge/deck bought complete, or is assembled from separate components. Whatever the method, the end result is that of extracting as much of the mechanical information from the LP as possible and converting it into an electrical signal which can, after amplification, induce the loudspeaker to re-create the original sound.

For this process three things are necessary: a turntable to rotate the LP at the correct speed, a signal producer (cartridge) to track, or follow, the recording groove and a means of holding that cartridge in exactly the right position above the record to enable it to do this accurately — the pickup arm.

The cartridge is the transducer, the device which converts one form of energy into another; it takes the vibrations from the stylus and produces an electrical output corresponding to that vibration. Figure 1 illustrates the method of operation.

Getting Turned

There are two main types of turntable on the market; direct-drive and belt-drive (Fig. 2), as well as two kinds of pickup arm (Fig. 3) and two leading cartridge varieties (Fig. 4). Thus it is better to ignore the myriad 'one-offs' such as moving iron cartridges and idler-drive turntables. As we are concerned here with choosing and using a first system, I think this is permissable.

To a large extent the operating method is irrelevant, much as it was with amplifiers, but because the disc-player is a considerably *less* refined product than the amp, differences between units is considerably *more* marked. Moving coil cartridges offer — in general — a more detailed and 'open' sounding result but at the cost of less secure tracking and looser bass (at the low end of the market, anyway). As with most things, differences become less general as the price goes up! Moving coils are more expensive to make superbly but the best is something truly wonderful! At up to around £100 a unit, it remains totally a matter of taste as to which type you will prefer.

If you read some of the hi-fi mags every month you will get the decided impression that there exists only one unit worthy of turning records around under a cartridge, but there are literally dozens of useful turntables available — all of which do the job very well indeed. Naturally some do it better than others, but cost and value for money vary enormously.

First Off

You'll probably be well advised to stick to an integrated deck at the beginning. A separate deck with added arm and cartridge *can* offer performance advantage, but will require setting up both initially and later on. If this thought induces spasms of panic — or even a moment's indecision — either find a friendly dealer or forget it for now. There is always time later, when upgrading — after building up some 'hands-on' experience.

So to specs and interpreting them. We'll take it one component at a time so that the information can be applied equally to both the integrated deck and to separates. As with amplifiers, if we haven't mentioned it below, it's irrelevant to sound quality and can be ignored!

Turntables

Quartz-locked: Direct-drive turntables need some form of speed stabilisation and early models compared the rotation with the ultra-stable mains frequency of 50 Hz to judge how accurately the unit was maintaining its speed. Later designs nearly all employ a crystal oscillator, like those used in watches for example, at around 2 MHz. This ensures a much higher degree of accuracy. Another advantage of this system is the provision of 'variable speed' or *Pitch Control* where the nominal 33⅓ RPM can be varied by a set percentage to allow correction of recording faults.

a

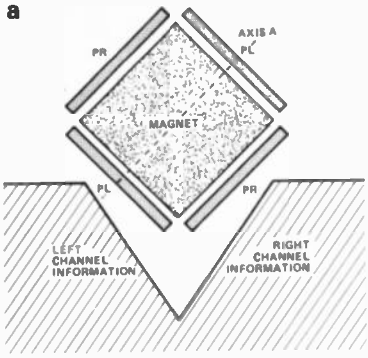


Fig. 1a The mechanical relationship between the pole pieces, the magnet and the record groove wall.

b

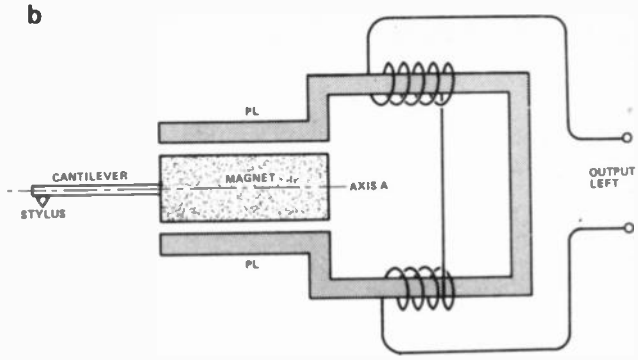


Fig. 1b Axis A can be referred to Fig. 1a to show the positioning of the generator within a moving magnet cartridge.

c

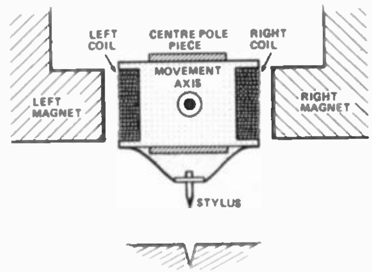


Fig. 1c. Moving coil basics. As the stylus moves the coils, a current is generated within them by the magnetic field from the fixed magnets.

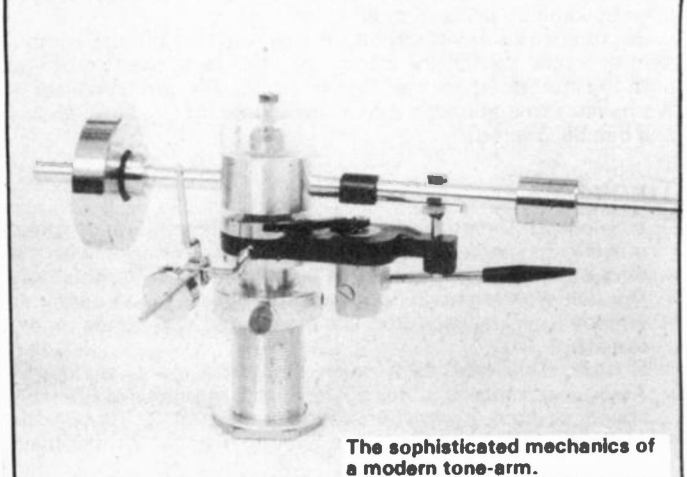
Wow And Flutter: As the turntable's main job is to rotate the LP at the correct velocity, any variations from that velocity can be considered as a form of distortion — it will render impossible the accurate replay of the source material on the record. There are two types of speed variation; (i) a sort of slow oscillation back and forth about the nominal value — noticeable on piano music in particular (wow); (ii) a short term variation, very rapid in nature (flutter) the speed of which can vary downward from a very fast unsettling waver in musical notes. Both are well under control in modern designs and figures of less than 0.5% are easily achieved. The best direct-drive designs can notch up less than 0.05%. Look for anything under 0.2%.

Rumble: A common feature of all turntable types is the bearing on which the platter (or record support) rests. Any sort of mechanical rotating system will vibrate to some degree or other and a turntable bearing is no exception. As the stylus is picking up mechanical information from the record, if the latter is vibrating unduly due to the bearing, this will be passed on to the amplifier and appear from the loudspeakers as a very low frequency growl — rumble.

Usually specified as a signal-to-noise ratio in decibels (dB), rumble should be only a minor problem on new units — but watch out for it on second-hand components! Look for figures over −45 dB unweighted, or −65 dB weighted.

Platter Mass: Simply the weight of the turntable upon which the record rests! More important on belt-drive units, where the mass is used like a flywheel to iron out minor variations in speed with sheer inertia. The best belt-drive units use somewhere around 6 lbs upwards. More important than actual weight is that the platter offers proper support to the LP. Mistrust any turntable mat that is not totally flat!

Damping/Insulation: It is obviously important to isolate the turntable from all outside vibration as much as possible in order that only the record groove causes the stylus to move. With direct-drive decks, where the motor is fixed to the plinth, this is more important than with the better belt-drive units, where the entire drive systems 'float' on isolating springs.



The sophisticated mechanics of a modern tone-arm.

Pickup Arms

Effective Mass: This is the mass that the stylus will have to pull behind it when following the record groove. This parameter is particularly important in matching the arm and cartridge. Cartridges with a high compliance (a large degree of flexibility) are best matched to arms with a low effective mass. However, some of the modern (particularly moving-coil) units have a low compliance and will give of their best in medium to high mass arms. This is because the arm and cartridge together form a mechanical 'tuned circuit' which will behave in much the same way as a capacitor-inductor electrical circuit does and will exhibit a resonant frequency — a particular frequency at which it is easier to move than any other. Thus the frequency response will not be linear but will show a preference for this resonant frequency. The range of resonant frequencies for most arm/cartridge assemblies lies between 5 Hz and 25 Hz. In order that audible frequencies are effected as little as possible, it is advisable to choose components which have a combined resonance below 20 Hz, but above 75 Hz, the frequency around which record warps usually occur. Table One gives you a range of effective masses and cartridge compliances and lists their resonant frequencies. Choose the arm/cartridge in your system to have a resonant frequency of between 10 Hz and 15 Hz and all will be well.

Bearing Friction: Usually quoted in two forms; lateral and vertical. As most pickup arms rely on two sets of bearings, one aligned in the same direction as the record surface and the other prependicular to it, both figures are important. They tell you the amount of 'drag' imposed by the arm when the cartridge tries to move it! Figures should be given in milligrams and are quoted as the force required to move the arm in a given direction (laterally across the record or vertical to it) when applied to the stylus. Look for something under 30 mg as good and don't use cartridges with a compliance of over 25 mg in an arm with any more than 30 mg friction!

Tracking (or Downforce) Range: Tells you what range of tracking weight can be applied to a cartridge fitted into the arm. Sounds simple enough, but also watch out that the actual weight of the cartridge you buy can be accomodated by the arm. Somewhere in the spec there will be a 'maximum weight' figure for matching cartridges. It is unwise to come close to this as your available tracking force will be limited.

Bias Compensation: Every arm should have some! Any object moving in a circle feels a force acting on it, trying to throw it away from the centre of the circle and a pickup cartridge is no exception. As the job of the arm is to keep the cartridge free of outside influences, by definition, it must counter this force. All a bias compensator does — usually with a hanging weight — is to pull the arm in the opposite direction to the force, theoretically by an exactly equal and opposite amount; this is determined by experimenting with a test disc. As long as the arm *has* a bias compensator — don't worry about it! Some integrated decks use springs or magnetic plates and possess a dial to add or subtract bias while the cartridge is playing a record. Nice, but unnecessary.

Lead Capacitance: Exactly what it says. The amount of capacitance added to the electrical load imposed upon the cartridge by the wiring from headshell to amplifier. Most car-a

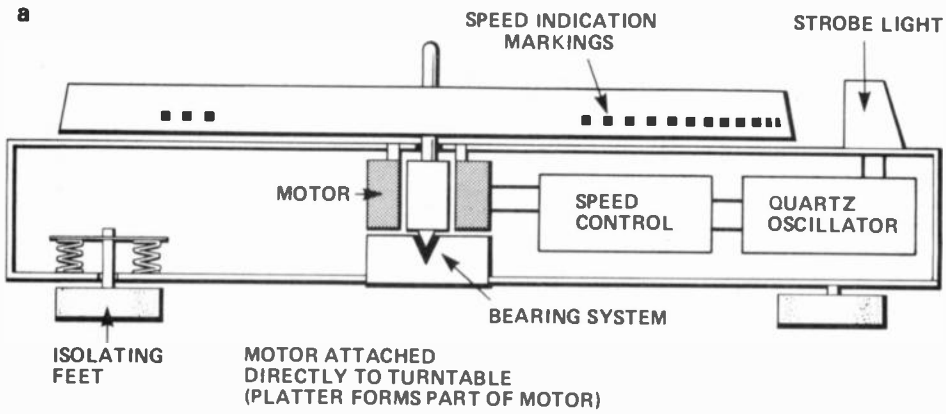


Fig. 2a. Schematic representation of a direct drive turntable. The 'dots' around the rim of the platter provide a visual check, by strobe-light, of the speed.

b

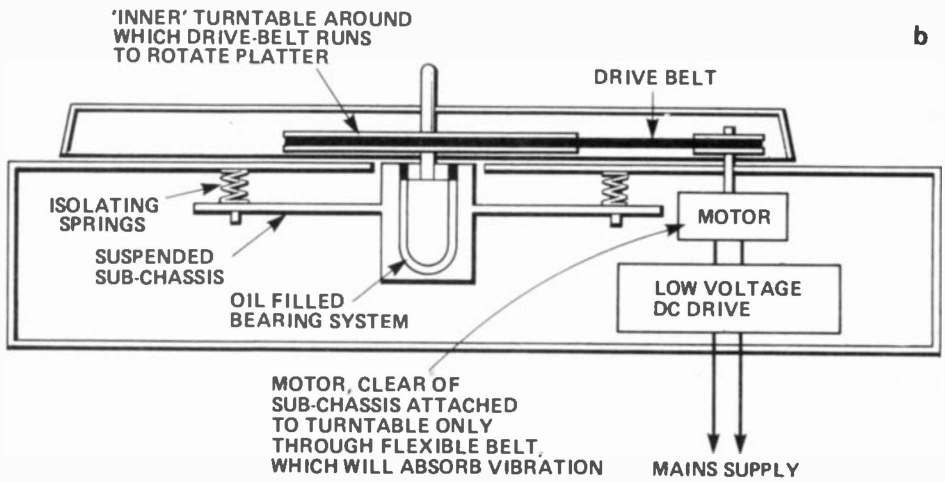


Fig. 2b. Schematic of a belt-drive turntable — 'older', but still capable of exceptional performance if correctly set up.

tridges are sensitive to this figure to some degree as the capacitance is like a mild frequency filter and 'rolls-off' the response. Unless you're making an expensive start to your hi-fi career by buying a system well up the price scale, it is generally safe to ignore this effect as it is very minor and not liable to effect the music on any but a very few units.

Tracking Error: As nearly all pickup arms are of the type where they pivot at a single point behind the turntable, it will be impossible for them to follow the path taken by the record cutting head used to produce the LP, as this is driven across in a straight line. However, with correct setting-up, the difference in the paths at any point on the record will be small — less than 2° in fact. On integral decks there is little the buyer has to worry about, things will have been worked out for him (hopefully) during manufacture. If you are assembling a deck from components, use the provided protractors — as outlined in our installation article — and all should be well. In reading reviews etc, look for a figure less than ±2°.

Adjustments: Take all you can get! The ability of a pickup system to operate at maximum efficiency depends upon its mechanical accuracy and alignment. A deck which allows you more freedom to 'tinker' probably also offers more chance to set it up correctly and thus earn a better sound quality!

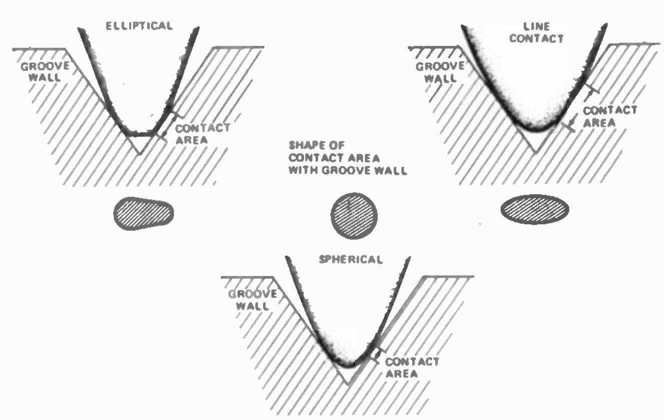
Cartridges

Compliance: A measure of the 'springiness' of the cantilever assembly that holds the stylus, ie how easily it bends! This is a good thing as far as following the record groove goes, but a bad thing when it comes to moving the weight of arm and cartridge along behind it. Thus there is no right or wrong value. High compliance means 'easily bent' and should be used only with low-mass arms. Compliance is measured in 'cu' (compliance units). Anything above 30 cu is high and anything under 15 cu is low. Shure moving-magnet pickups average 30-40 cu and the best moving-coils under 10 cu! A high arm mass is anything over 15 grams, with anything less than 10 grams being considered low mass. Read back over the section on effective mass and take a look at Table One, which illustrates the interaction between these two parameters.

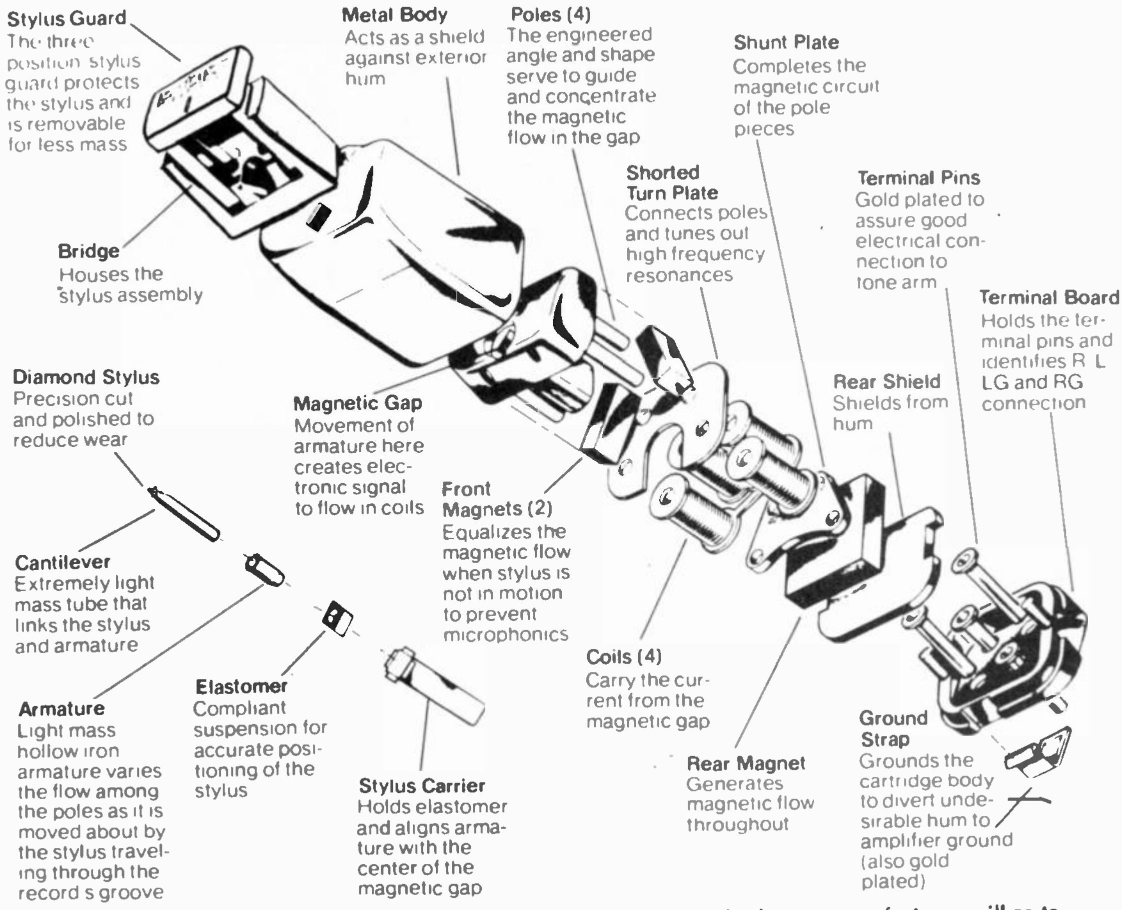
Tip-Mass: Is the weight of the actual stylus as seen by the groove walls! This will determine record wear — and how well the stylus can stay in the groove at high frequencies, since there will be a second resonance here somewhere above 15 kHz. The higher this resonance (lower tip mass) the better, to some degree — suspect any figure less than 20 kHz!

Output Level: There is no figure current for how much voltage a cartridge should generate; it will depend on the amp it is to feed. Figures are generally quoted in terms of millivolts output at 5 cm/sec recorded velocity. An average moving-magnet design will develop around 3 mV at 1kHz and a moving-coil substantially less. Look to match the quoted figure with the amplifier input sensitivity and you won't go far wrong!

Frequency Response: As with amplifiers, a measure of 'flatness' or freedom from uneven treatment of an input. The cartridge should replay any frequencies between 20 Hz-20 kHz at an equal level. The limits (in dB) quoted with the figure — ignore it if there *are* no limits — show how close the unit comes to



The three most common stylus profiles and their relative parameters. Note that whilst the elliptical offers a greater ability, its area of contact will generate increased record wear.



This exploded view of an Empire cartridge gives an indication of the lengths that top manufacturers will go to in order to beat reasonances and colourations.

meeting this requirement. Look for ± 2 dB maximum across 20 Hz-20 kHz.

Distortion Figure: As the cartridge is a transducer, it will impart some distortion to the signal during its transformation. Figures generally quoted are for Intermodulation Distortion — how much one note will effect another when replayed simultaneously — and Total Harmonic Distortion, which is the degree to which a pure sine wave going in is less than pure coming out! Look to better 2% on all distortions figures.

Cash Considerations

With an integral deck, assign 30 percent of your budget to the record player and cartridge. As separates will initially be more expensive, assign 35 percent of the total if you choose this option. The extra comes from the speaker allowance, on the grounds that, as you are in the upgrading game anyway, you will wish to improve them later on. The extra cash will make more audible difference at the source, initially.

Arms And The Man

Integrated decks offer the advantage that they require little, if any, setting up. Generally speaking, there is little the user can adjust, except the cartridge alignment in the headshell. If you have decided on such a machine then read carefully through the adverts in the hi-fi press from the larger dealers. Many of them run package deals, at very attractive prices, which comprise either an integrated deck with a good cartridge or even separate turntable/arm/cartridge set-ups, pre-assembled and pre-chosen to make things easy!

In just about every case, a Far Eastern machine will arrive with a pre-fitted cartridge. Throw it out! (or, at best, save it for a spare). Such offerings are usually of little value compared to the deck itself and are one reason why many dealers offer the aforementioned deals. Choose your own cartridge following the dealer's advice as to compatibility with the selected deck. If in doubt, ring up the manufacturer of the turntable and ask them whether your proposed cartridge is compatible. You'll be surprised at how helpful hi-fi companies can be!

Separate disc-playing components are more trouble to choose, but offer much greater flexibility — and quality — later on. The problem is made irrelevant to some extent by the scarcity of good quality turntables, without an arm, at anything less than a king's ransom. No matter what the advertising may tell you, spending £400 on a turntable in a £600 system is sheer lunacy. It makes sense only if you're selling turntables! Given the level of other components in the system it would be impossible to distinguish, say, the Oracle at £680 from the TD 160 BC at £110. Keep a sense of proportion.

It is absolutely essential that you hear the cartridge you want together with your proposed loudspeakers. These two components are the ones most likely to possess a strong 'character', or sound of their own.

For example, a number of budget loudspeakers can sound a trifle dull and lifeless, while still being good value for the money. Partnering these with a bright sounding cartridge can produce an overall result which is pleasing and more accurate.

It doesn't matter which you fix on first, speaker or cartridge, but choose them together. You may, for instance, decide that because space in the home is limited, you need compact enclosures of below a certain size. Once more, make up a shortlist and audition a few with the same cartridge. Then get the cartridge changed. After a few minutes the combination which appeals to you most will become apparent.

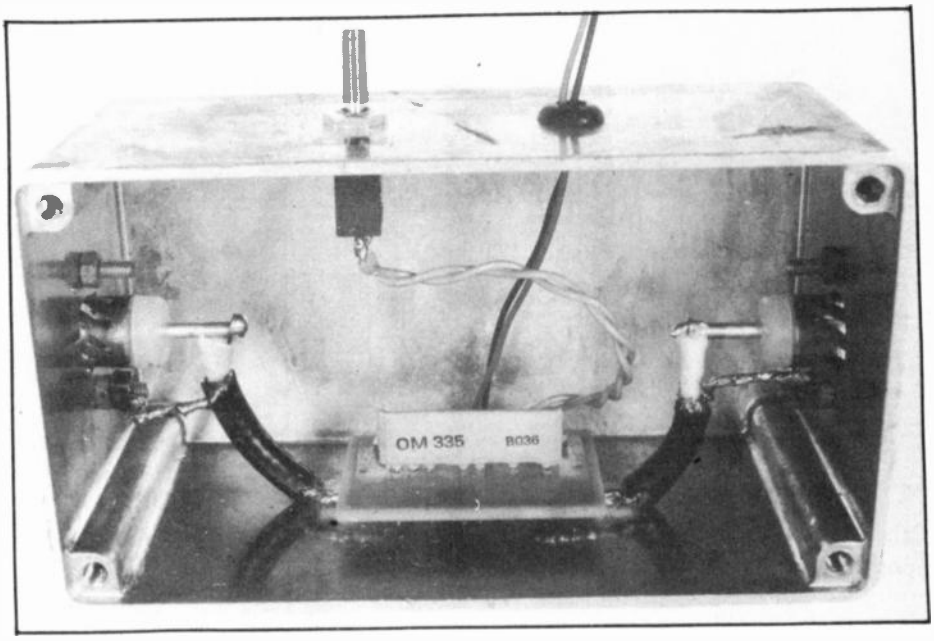
Pick Up Pickups

With the advent of the new generation of moving-coil cartridges and their higher outputs, it is feasible to use such a device in a first system. However, don't be tempted to buy a cartridge simply because it is a moving-coil unit. The mode of operation is totally irrelevant; it is the sound that matters and if you prefer some other type of unit, go buy it.

By all means consider specification seriously, especially with regard to matching up units, but don't let one single line of ad copy or formulae decide which hi-fi you buy. Let your ears do the choosing for you! This is especially important when it comes to loudspeakers, as we shall see next month. **HE**

MASTHEAD AMPLIFIER

A special project for campers or caravanners who like to watch their portable TV when away on holiday trips, but find that it's sometimes difficult to get good TV-reception



WE APPRECIATE that it's not always possible to pick up a good TV signal from a set-top TV aerial because so much depends on distance from the nearest TV transmitter and the local terrain. If you find, when you're on holiday trips, that your TV picture often suffers from a weak signal then you may be interested by this project.

Given the right conditions, the HE Aerial Preamplifier can increase the size of the signal picked up by your aerial and thus improve the signal-to-noise ratio, allowing a good picture to be displayed. Of course, if the aerial signal is *too* small, no amount of amplification will do the job. However, the improvements which our project offers will certainly help you to maintain good reception in all but the poorest areas.

As you can see from the description in How It Works, the OM335 has a bandwidth which extends down to VHF frequencies. Consequently this preamplifier may also be of interest to people who have problems with FM radio reception.

Any voltage within the range of 10 V to 24 V will power the preamplifier, so a car battery — the same one used to run the TV — is ideal. We haven't given a circuit diagram of the project, because the circuit is so simple: a single IC! All the components which make up the circuits — the capacitors, resistors and transistors — are contained within the IC's body. The IC is what's known as a hybrid IC (the term 'hybrid' tells us that it is made up of individual discrete components), and **no other** components are required to build up the project. **Figure** 1 shows the pin configurations of the IC.

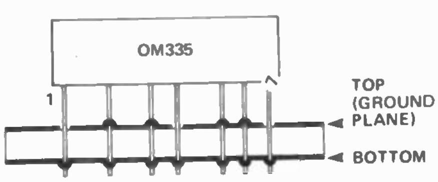


Figure 1. Pin configuration of the OM355 IC, with a cross-section through the board showing pins 2, 3, 5 and 6 soldered both sides.

Make sure the body of the IC fits as close to the board's surface as you can get if before soldering it in and DON'T OVERHEAT THE DEVICE! Solder one pin at a time, then let it cool for a few minutes before soldering the next. **Figure** 2 shows the PCB overlay. The PCB is double-sided (ie, there is a copper foil pattern on both surfaces) so make certain you insert the IC in to the correct surface.

The upper copper surface (the ground plane) should be at 0 V, which is achieved by soldering pins 2,3,5 and 6 on both sides of the board. Use good quality 75R co-axial cable to connect between the board and the co-axial sockets. Solder a short length (about 2") of cable to each end of the board — screen to the outside earth, as shown in **Figure** 2and the signal or centre lead of the cable to the centre connection of the PCB track. Make sure there are no solder bridges across tracks.

Now wire up the power lead from the board to the switch and out of the box. Make sure you get the leads the right way round.

Construction

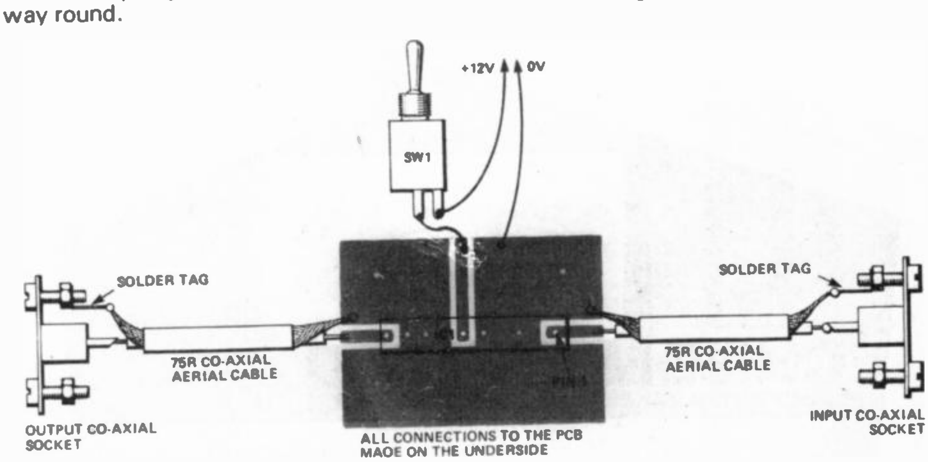
Mark and drill the die-cast box to fit the switch, the grommet, the two co-axial sockets and the PCB mounting bolts.

Use the PCB exactly as shown and follow the instructions carefully. This is important because high-gain, high-frequency amplifiers can cause interfering oscillations if they aren't correctly mounted. The PCB foil pattern is specially designed to prevent oscillation and *must* be used — and don't forget the ground plane connections on the component side of the board!

Mount the complete, wired PCB into the case and onto the mounting bolts.

Solder the two co-axial leads to their corresponding sockets, bolt on the bottom of the box and you're ready to go.

Figure 2. Component overlay.

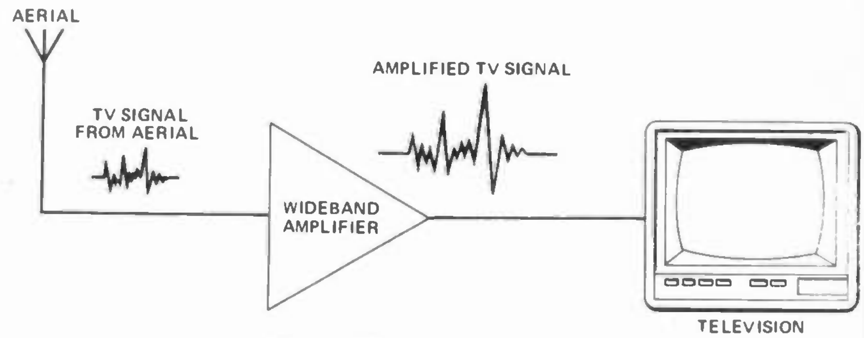


How It Works

Integrated circuit IC1 is a wideband amplifier, the gain of which is about 18 times. Any signal picked up by the aerial within the frequency range of 50-900 MHz is amplified by the IC — thus all standard British 625-line TV transmissions are covered.

The actual theory behind the operation of a TV preamplifier is complex, but can be simplified in general terms. In effect, any amplifier is only as good as the input signal — if the signal is noisy then the amplifier output will also be noisy, only bigger.

In the case of an amplifier fed by a long input lead (which adds noise), the output signal is a combination of equally amplified signal plus noise. If, however, the amplifier is at the other end of the lead (ie, before the noise occurs) then the signal is amplified *but not the noise.* This means that the signal is proportionally larger than the noise and we can say that the signal-to-noise ratio has increased.



Buylines

The OM355 is availble from RS Components. All the other parts are easily obtained.

Connecting The Preamplifier

Figure 3 shows the example of how the preamplifier may be connected if the TV has an existing set-top aerial.

If your portable TV aerial is mast-mounted (as is sometimes the case in fixed caravan sites), Figure 4 shows suitable connection details.

Best-possible performance will be obtained when the preamplifier is mounted as close to the aerial as you can get it. Therefore, if you do have a mast-mounted aerial, it is advisable to mount the preamplifier at the top of the mast as well. For outside use the box should be mounted upside down and the edges sealed with waterproof sealant.

Incidentally, if you live in a poor TV-reception area and the aerial on your roof isn't able to pick up strong enough signals to allow a good TV picture, then you may find this project can help. Mast-mounting the preamplifier (or perhaps putting it in your attic) as close as possible to the aerial and powering it from a mains-to-DC supply could give you a much improved picture signal.

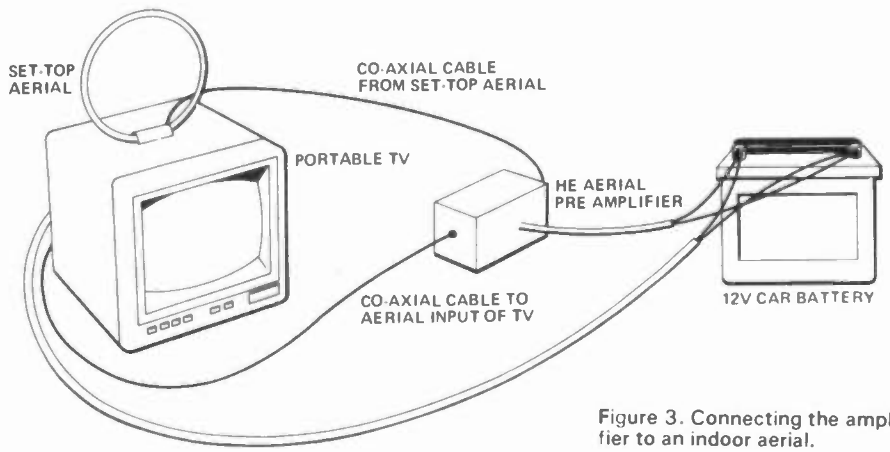


Figure 3. Connecting the amplifier to an indoor aerial.

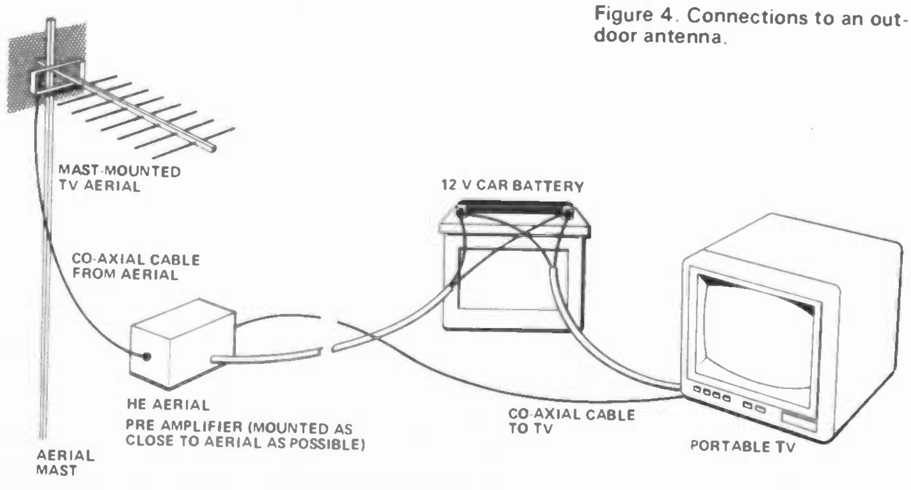


Figure 4. Connections to an outdoor antenna.

Parts List

SEMICONDUCTORS

IC1 OM335 wideband amplifier

MISCELLANEOUS

SW1 single-pole, single-throw toggle switch

2 x chassis-mounting co-axial sockets

Rubber grommet

Nuts and bolts

Die-cast aluminium case: 4" x 2" x 2"

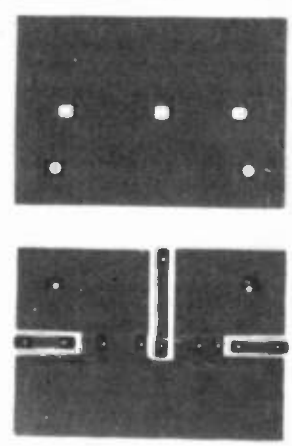


Figure 5. Top (upper diagram)and bottom (lower) PCB foil patterns, viwed from the top and bottom, respectively.

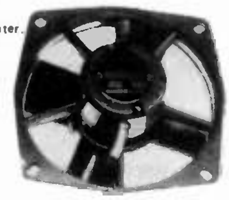
THIS MONTH'S NEW KITS

For the musically inclined	
Drum Synthesiser	£29.50
Mixer/Pre Amp	£16.00
Stylus Organ	£4.95
For the Service Engineer	
Micro Volt Multiplier	£3.95
Sign Wave Generator	£5.75
Linear Power Output Meter	£11.50
For the Ham or CB Enthusiast	
Aerial Rotator	£24.50
Aerial Direction Indicator	£5.90
For the Motorist	
Electronic Ignition Kit	£19.50
For all of you	
Electric Jigsaw Puzzle	£5.30
Blow Heater Kit	£6.45
And if you are having TV Interference Problems	
High-Pass Filter	£1.95
Low-Pass Filter	£3.45

UNIVAC KEYBOARD BARGAIN
Ideal for use with ZX80/81. Has 50 keys and many other parts for your spares box. Probably cost in excess of £100. In very good used condition — £13.50 + £2.00 post. Diagram showing how to connect to ZX80/81 — £2.00 extra.

COMPUTER DESK


Size approx. 4' x 2' x 2'6" high. These were made for hard work, the top being formica covered. Suitable for housing instruments or for use as office desks. Beautifully made, these cost over £100 each, our price only £11.50 each, however, you must arrange to collect.

EXTRACTOR FANS


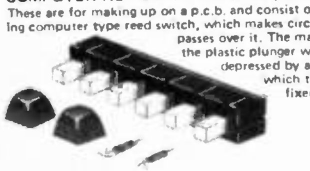
Mains operated — ex. Computer.
5" Woods extractor £5.75 Post £1.00.
6" Woods extractor £6.90 Post £1.25
6" Plannair extractor £7.50 Post £1.00
4" x 4" Muffin 115v. £4.50 Post 50p.
4" x 4" Muffin 230v. £5.75 Post 50p.

INTERRUPTED BEAM
This kit enables you to make a switch that will trigger when a steady beam of infra red or ordinary light is broken. Main components — relay, photo transistor, resistors and caps, etc. Circuit diagram but no case. Price £2.30

INSTRUMENT BOX WITH KEY
Very strongly made (ply-wood sides with hard board top and bottom). This is black grained effect, vinyl covered, very pleasing appearance. Internal dimensions 12½" long, 4¾" wide, 6" deep. Ideal for carrying your multi range meter and small tools and for keeping them in a safe place. £2.30. Post paid if ordered with other goods, otherwise £1.00.

ROPE LIGHT
4 sets of coloured lamps in translucent plastic tube arranged to give the appearance of a running or travelling light. With variable speed control box, ideal for disco or shop window display. Complete, made up, ready to plug into mains. £36.00 + £2 post.

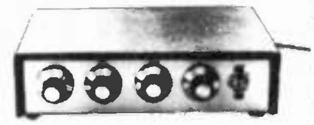
COMPUTER KEY SWITCHES (make your own keyboard)
These are for making up on a p.c.b. and consist of a vertical mounting computer type reed switch, which makes circuit when a magnet passes over it. The magnet is located in the plastic plunger which in turn is depressed by a push rod, to which the legended top is fixed. These are made up in banks of 6, price £2.30 per bank of 6 (including tops)



OUR CAR STARTER AND CHARGER KIT has no doubt saved many motorists from embarrassment in an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises: 250w mains transformer, two 10 amp bridge rectifiers, start/charge switch and full instructions. You can assemble this in the evening, box it up or leave it on the shelf in the garage, whichever suits you best. Price £11.50 + £2.50 post.

GPO HIGH GAIN AMP/SIGNAL TRACER. In case measuring only 5¾in x 3¼in x 1¾in is an extremely high gain (70dB) solid state amplifier designed for use as a signal tracer on GPO cables, etc. With a radio it functions very well as a signal tracer. By connecting a simple coil to the input socket a useful mains cable tracer can be made. Runs on standard 4½v battery and has input, output sockets and on-off volume control, mounted flush on the top. Many other uses include general purpose amp, cueing amp, etc. An absolute bargain at only £1.85. Suitable 80ohm earpiece 69p.

FREE OUR CURRENT BARGAIN LIST WILL BE ENCLOSED WITH ALL ORDERS.

3 CHANNEL SOUND TO LIGHT KIT


Complete kit of parts for a three-channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two-tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four-pin plug and socket facilitate ease of connecting lamps. Special snip price is £14.95 in kit form or £25.00 assembled and tested.

MULLARD UNILEX


A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone. In easy to assemble modular form this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only £16.75 including VAT and post. FREE GIFT — buy this month and you will receive a pair of Goodman's eliptical 8"x5" speakers to match this amplifier.

THIS MONTH'S SNIP
POCKET AUDIO COMPONENT TESTER


With it you can quickly test diodes, rectifiers, transistors, capacitors, check wiring and p.c. boards for open circuits, find the anode and cathode of a diode or rectifier and whether a transistor is PNP or NPN, which are the base collector and emitter connections. Condensers, if bad, give a continuous signal, but if good, give intermittent signals of varying length depending on their value. The test current is very low (2uA) and the voltage only 1.4v, so it is also possible to check MOS devices, as well as sensitive transistors without fear of damaging them. The unit is supplied complete with internal battery, which should last many months.
Price £3.45p

THERMOSTAT ASSORTMENT
10 different thermostats. 7 bi-metal types and 3 liquid types. There are the current stats which will open the switch to protect devices against overload, short circuits, etc., or when fitted say in front of the element of a blow heater, the heat would trip the stat if the blower fuses, appliance stats, one for high temperatures, others adjustable over a range of temperatures which could include 0 — 100°C. There is also a thermostatic pod which can be immersed, an oven stat, a calibrated boiler stat, finally an ice stat which, fitted to our waterproof heater element, up in the loft could protect your pipes from freezing. Separately, these thermostats could cost around £15.00 — however, you can have the parcel for £2.50.

6 WAVEBAND SHORTWAVE RADIO KIT
Bandspread covering 13.5 to 32 metres. Based on circuit which appeared in a recent issue of Radio Constructor. Complete kit includes case materials, six transistors and diodes, condensers, resistors, inductors, switches, etc. Nothing else to buy if you have an amplifier to connect it to or a pair of high resistance headphones. Price £11.95.

MEDIUM & 2 SHORT WAVE CRYSTAL RADIO
All the parts to make up the beginner's model. Price £2.30. Crystal earpiece 65p. High resistance headphones (gives best results) £3.75. Kit includes chassis and front but not case.

TRANSMITTER SURVEILLANCE
Tiny, easily hidden but which will enable conversation to be picked up with FM radio. Can be made in a matchbox — all electronic parts and circuit. £2.30. (Not licenceable in the U.K.).

RADIO MIKE
Ideal for discos and garden parties, allows complete freedom of movement. Play through FM radio or tuner amp. £6.90 comp. kit. (Not licenceable in the U.K.)

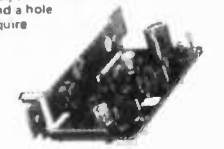
RADIO STETHOSCOPE
Easy to fault find — start at the aerial and work towards the speaker — when signal stops you have found the fault. Complete kit £4.95.

MUGGER DETERRENT
A high-note bleeper, push latching switch, plastic case and battery connector. Will scare away any villain and bring help. £2.50 complete kit.

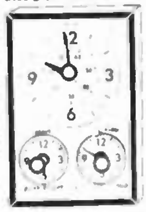
POPULAR SNIP — STILL AVAILABLE
And it still carries a free gift of a desoldering pump, which we are currently selling at £6.35p. The snip is perhaps the most useful breakdown parcel we have ever offered. It is a parcel of 50 nearly all different computer panels containing parts which must have cost at least £500. On these boards you will find over 300 IC's. Over 300 diodes, over 200 transistors and several thousand other parts, resistors, condensors, multi-turn pots, recifiers, SCR, etc. etc. If you act promptly, you can have this parcel for only £8.50, which when you deduct the value of the desoldering pump, works out to just a little over 4p per panel. Surely this is a bargain you should not miss!
When ordering please add £2.50 post and £1.27 VAT.

BURGLAR ALARM CONTROL PANEL
Contains labelled connection block, latching relay, test switch and removable key control switch. Simplifies the whole installation, all you have to do is to take wires to pressure pads and to alarm bell. Price £7.95, with complete diagram.

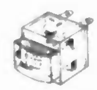
MINI MONO AMP
on p.c.b., size 4" x 2" approx. Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amplifier. Brand new, perfect condition, offered at the very low price of £1.15 each, or 10 for £10.00.



DELAY SWITCH
Mains operated — delay can be accurately set with pointers knob for periods of up to 2½hrs. 2 contacts suitable to switch 10 amps — second contact opens a few minutes after 1st contact. £1.95.



TIME SWITCH BARGAIN
Large clear mains frequency controlled clock, which will always show you the correct time + start and stop switches with dials. Complete with knobs. £2.50.

LEVEL METER


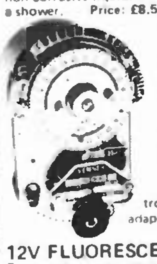
Size approximately ¾" square, scaled signal and power but cover easily removable for rescaling. Sensitivity 200 uA. 75p.

WATERPROOF HEATING WIRE
60 ohms per yard, this is a heating element wound on a fibre glass coil and then covered with p.v.c. Dozens of uses — around water pipes, under grow boxes in gloves and socks.

TANGENTIAL BLOW HEATER


2.5 Kw quiet, efficient instant heating from 230/240 volt mains. Kit consists of blower as illustrated, 2.5 Kw element, control switch and data all for £4.95, post £1.50.

12V SUBMERSIBLE PUMP
Just join it to your car battery, drop it into the liquid to be moved and up it comes, no messing about, no priming, etc. and you get a very good head. Suitable for water, paraffin and any non-explosive non-corrosive liquid. One use if you are a camper, make yourself a shower. Price: £8.50.

VENNER TIME SWITCH


Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95. These are without case, but we can supply metal case with window £2.95.
Also available is adaptor kit to convert this into a normal 24hr time switch but with the added advantage of up to 12 on/offs per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30. Post any or all items £1.

12V FLUORESCENT LIGHTING


For camping — car repairing — emergeny lighting from a 12v battery you can't beat fluorescent lighting. It will offer plenty of well distributed light and is economical. We offer an inverter for 21" 13 watt miniature fluorescent tube. £3.45. (tube not supplied).

FIVE UNUSUAL SWITCHES
For inventors, experimenters, service engineers, students or in fact anyone interested in making electrical gadgets. The parcel contains: — delay switch — motor driven switch — two-way and off switch — polarity changing switch — and humidity switch. Our regular price for these switches bought separately is over £10, but this month you can have the 5 for £2.50.

SPIT MOTORS


These are powerful mains operated induction motors with gear box attached. The final shaft is a ½" rod with square hole, so you have alternative couplingmethods — final speed is approx. 5 revs/min, price £5.50. — Similar motors with final speeds of 80, 100, 160 & 200r.p.m. same price.

COMPONENT BOARD
Ref. WO998
This is a modern fibreglass board which contains a multitude of very useful parts, most important of which are: 35 assorted diodes and rectifiers including 4 3amp 400v types (made up in a bridge) 8 transistors type BC 107 and 2 type BFY 51 electrolytic condensers. SCR ref 2N 5062, 25 Ouf 100v OC and 100uf 25v DC and over 100 other parts including variable, fixed and wire wound resistors, electrolytic and other condensers. A real snip at £1.15.

J. BULL (Electrical) Ltd.
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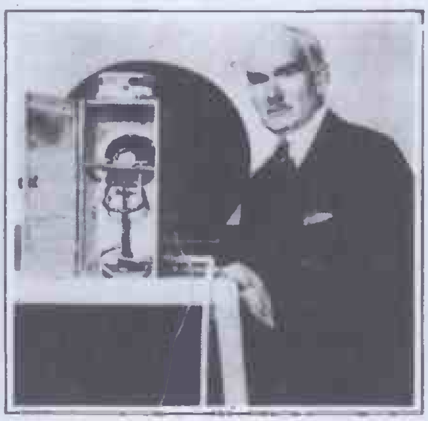
MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £10.00, add 60p service charge. Monthly account orders accepted from schools and public companies. Access & Barclaycard orders phone Haywards Heath (0444) 54563. CALLERS: to Haywards Heath (closed Sat.), or 2, Bentham Road, Off Elm Grove, Brighton (closed Wed.). BULK ORDERS: Write for special quotation. Normally delivery is by return.

FAMOUS NAMES

Lee De Forest was a brilliant and prolific inventor in the days when electronics and chemistry weren't quite-so-separate sciences.

LEE DE FOREST was born in 1873 in the country town of Council Bluffs, Iowa. His father was a congregational minister and while Lee was still very young, the family moved to Alabama where his father ministered to a congregation which was wholly made up of black families, many of them former slaves. In the atmosphere of the 1870's, with the smoke of the Civil War hardly dissipated and recriminations still ringing bitterly round the South, this was a remarkably courageous thing to do. The Rev De Forest became very widely respected among the black community but was totally outcast in the eyes of the white majority so that Lee, shunned by white boys of his own age, was brought up entirely in the company of black children.

Lee proved to be remarkably inventive and, by the age of thirteen, he was credited with three inventions which he had demonstrated in model form. As a result of this and the promise he had shown at secondary school, he was one of the first students to enrol in the School of Scientific Studies (the Sheffield School) at Yale University in 1893. This was one of the earliest specialised courses in Science and, as far as we can tell, Lee was fascinated by the work though his undergraduate career, as is often the case, was not marked by any traces of brilliance. Undistinguished is a kind phrase for it. He graduated, however, and went on to further study for a PhD, starting to show the sort of ability for which he is now remembered. His PhD thesis was something of a watershed in the history of electronics. His interest in the work of Heinrich Hertz and Marconi directed his attention to the study of radio waves; the title of his thesis was "Reflection of Hertzian Waves from the Ends of Parallel Wires". Sound familiar? Yes, that's the VSWR business that radio hams and all the CB'ers talk about! De Forest's thesis was the first accepted in the USA for a PhD degree which dealt with the new subject of radio. That alone should be enough to make him known as a pioneer.



Lee De Forest with his "Flame" microphone which he developed in 1923 for the Phonofilm.

Acid Test

De Forest left Yale to join the Western Electric Corporation; then, as now, very active in all forms of communication involving electricity. He started in the dynamo department but, because of his particular interest in the new technology of radio, moved — first to the telephone department, then to the research department. While there, he worked on the problem of the detection of radio waves, one of the major stumbling-blocks of early radio.

Remember that, at the time, all radio was telegraphic — there were no speech transmissions and Morse Code ruled OK?! The problem was to detect the 'dots' and 'dashes' of a Morse transmission and the standard method used a device called a 'coherer'. This was a coil wrapped around a tube of iron filings; a strong enough radio signal, passed through the coil, made the filings cling together (cohere) and in this condition they would pass enough DC current to operate a telegraphic receiver or a sensitive earphone. The DC current also operated a small hammer to loosen up the particles, ready for the next transmission pulse. It was clumsy but it worked, although it wasn't exactly sensitive!

De Forest is credited, in the US, with the invention of the Electrolytic Detector, which used two different metals dipping into a solution of acid. The principle was that such a cell passes current more easily in one direction than in the other so that, like a diode, it could rectify radio waves and provide a DC output. The same detection principle had been used earlier, in Britain, by Fleming.

By 1902, De Forest felt confident enough in the future of radio as a commercial proposition to set up his own company. The De Forest Wireless Telegraph Co., was the first to give a public demonstration of radio in the USA, but the company went bankrupt in 1906.

Audion-ics

In 1907 De Forest patented his Audion, a three element vacuum valve, the device for which he is famous. Fleming had introduced the valve diode in 1904 but the addition of a third electrode, the 'grid', made it possible to control the current passing through the valve between anode and cathode, making amplification possible. This was undoubtedly one of the most important steps in all the history of electronics but the company which De Forest set up to exploit his invention suffered the same fate as his earlier enterprise, and was declared bankrupt in 1909. In retrospect, he tried to do too much too soon.

Then, in a ludicrous court case De Forest was charged with "using the US mail to promote a worthless device". The "worthless device" was the Audion! Fortunately, he was acquitted of the charge.

Free once more to concentrate on radio, he worked to perfect the Audion and later in 1912, was able to show that huge amounts of amplification could be obtained by cascading Audions, using the output of one as the input for another. This inevitably led him to invent another device for which he deserves to be remembered — the oscillator.

In 1920 he was able to demonstrate a sound-on-film system for the movies and, had he been able to press his achievement on the ignorant and unconvinced studio bosses of the day, he would certainly be remembered for this achievement too. As it was, his system was rejected in favour of crude schemes using gramophone records and it was only in 1928 that the first true sound films were made. Even then De Forest's method was not used until the 30s; there was no benefit to him, then, for having been the pioneer.

Late in life, De Forest was still a keen and gifted researcher. In the 30s he worked on the medical uses of high-frequency signals, designing what are now known as diathermy (deep heat) machines and contributing to the techniques of inductive and capacitive heating which played such an important part in the war effort. During World War II, by now a legendary figure, he directed research at the Bell Telephone Laboratories, one of the most famous and successful research laboratories in the world. There, in 1947, the first working transistor was constructed. De Forest saw all this and must have wryly compared the fortunes of Shockley and his team with his own experiences. He died in 1961, having seen the pioneer years of radio develop into the full flower of electronic science that we know today. His one regret was that he never received a Nobel Prize, though his name was put forward on several occasions.

Picture courtesy of "Sounds Vintage" magazine.

INTO ELECTRONIC COMPONENTS

In Part 7 we take a look at the How, Why and What of transistors.

TRANSISTORS HAVE BEEN around for a long time, since 1948 in fact, which makes them a good bit older than a lot of us! We don't use transistors (as separate components) as much as we once did, thanks to the IC, but it still helps if we know a bit about them, partly because ICs are made out of collections of transistors.

A transistor starts out, like a diode, as a crystal of silicon which has been doped either P or N. To give an example, let's follow the set of operations which are performed on a chunk of N-type crystal that is about to become a transistor. Starting with N-type gives us an NPN transistor; if we started with P-type we would end up with a PNP transistor.

The first step is to oxidise the surface by heating the crystal to a high temperature in water vapour at low pressure. Oxidising silicon will produce silicon oxide, (one form of which is sand) but when it's done in this way the result is a tough surface film of transparent oxide which protects the silicon underneath. The next step is to cut a hole in this film. We don't use anything as crude as a drill, though, because the layer of oxide is very thin and the technique called photoetching is much more precise. A layer of photoresist liquid is put on the surface and allowed to partly solidify; this liquid is a near-relative of the stuff that is used for making printed circuits boards and it hardens totally when exposed to ultra-violet light from a mercury lamp. If we clamp a photographic negative to the coated slilicon and expose it to ultra-violet (UV for short), we can 'print' the pattern of the negative on to the photoresist. The photoresist can then be washed away, where it has not been exposed to the UV. The material which has been hardened by exposure to UV will not wash away, however, but remains as a 'mask', protecting the silicon oxide.

Protecting? Yes, because the hardened resist is resistant to acid — which is why we call it 'resist', but the silicon oxide layer — tough as it is — will dissolve easily even in dilute acids.

By dipping the chip in acid, we can now etch away the silicon oxide which was not hardened by exposure to UV. This etching process exposes the silicon (which is N-type, remember) underneath, but has no other effect because silicon itself is not attacked by dilute acid (**Figure 7.1**).

Next step is called 'epitaxy'. We remove the rest of the photoresist by dissolving it, in a liquid that has no effect either on the silicon or on the remaining silicon oxide, and then heat the chip in a container which has some vapour of P-type silicon in it. The P-type vapour condenses on the exposed silicon, but not on the silicon oxide. Where it touches the N-type, however, the P-type silicon joins on, forming a thin film of P-type material which looks as if it was always part of the same crystal. It is possi-

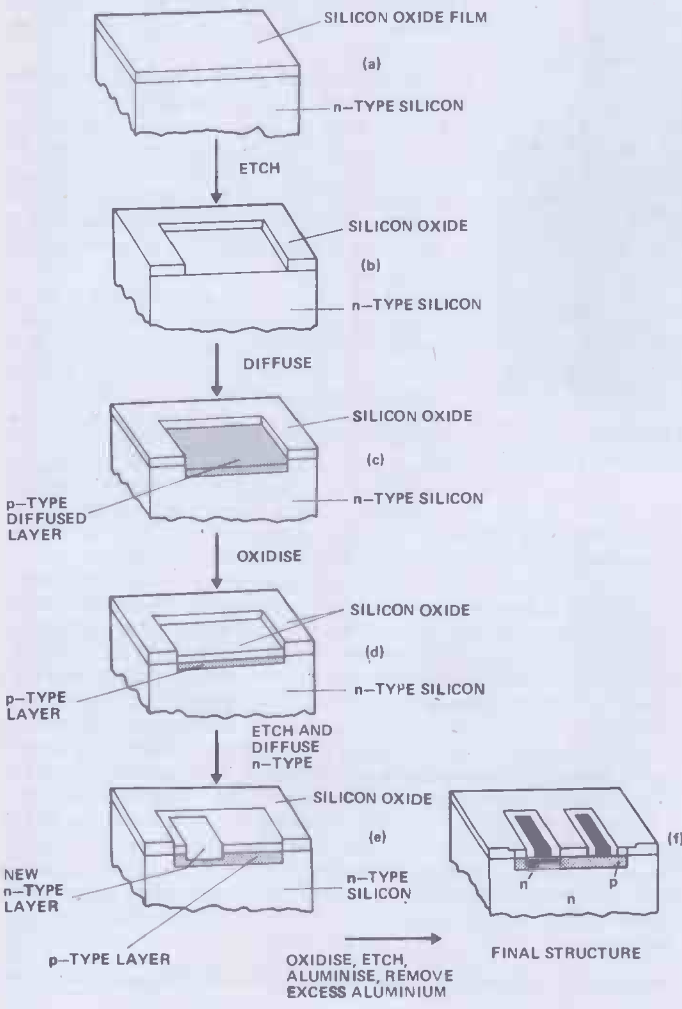


Figure 7.1. The process of oxidising and the use of photoresist allows us to etch patterns of exposed silicon.

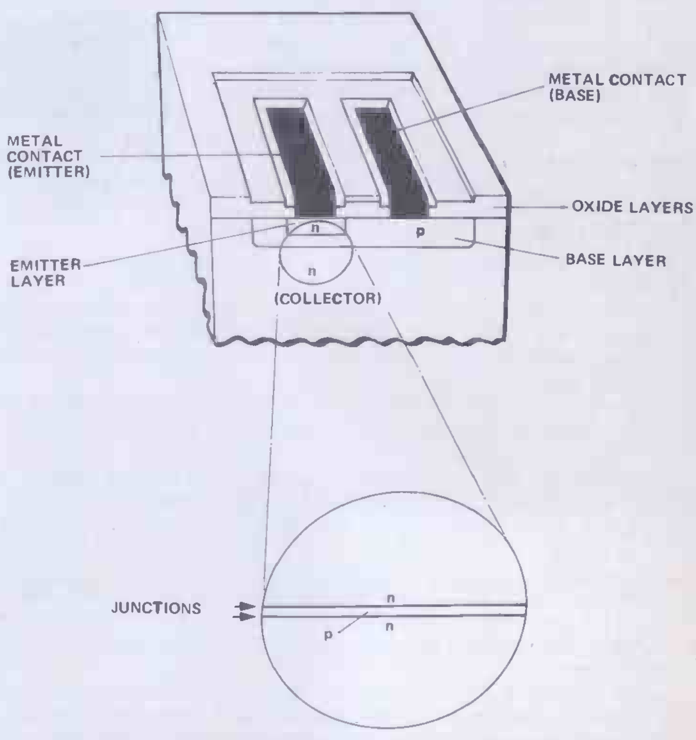


Figure 7.2. The shape of the complete set of patterns for an NPN transistor. Contact is made through aluminium 'pads'

ble to accurately control the thickness of this layer, which will become the base of the transistor, by controlling the temperature and the pressure of the P-type silicon vapour in the container.

The next step is to oxidise the P-type silicon again, and to coat the surface with the photo-resist once more. Another pair of holes are now cut through the oxide, using a different 'negative' pattern and once again etching through the oxide. One of these holes has aluminium deposited in it, to form a contact to the P-type layer (which is the base of the transistor), the other one has N-type silicon deposited in it by heating the chip in a container with the vapour of N-type silicon. Following, this aluminium is deposited on top of the N-type material to form a contact to this layer, which becomes the emitter of the transistor (**Figure 7.2**). The collector connection is to the main slab of N-type material.

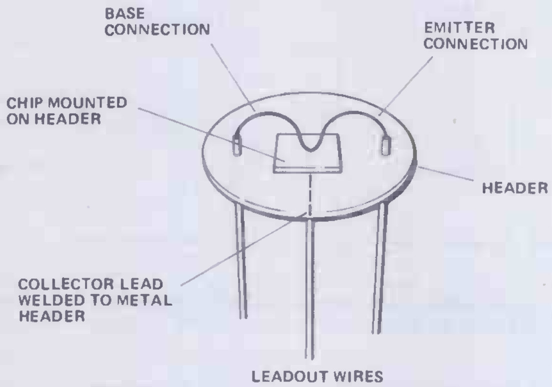


Figure 7.3. The chip mounted on its header. If a metal header is used, the collector connection is made by soldering the chip to the header

The process is carried out on several hundred chips at one time, so that each set of operations produces a large number of transistors. Once tested, the chips are mounted on 'headers' with a thin gold wire used to weld connections to the base and the emitter layers (to the aluminium surfaces, which can be spot-welded much more easily than silicon) and the collector connection is made by soldering to the main N-type slab of material. Finally the header is enclosed in a metal or plastic case, thus protecting the chip from damage by exposure to air or by having its fragile connecting wires knocked out of place. A contact to each part of the transistor, N, P, and N, gives a total of three connections. Now, with the two connections of a diode, there were only two resistance readings that could be taken — one in each direction across the two terminals. When we have three terminals, six resistance readings (taken two terminals at a time) are possible — the results of typical readings are shown in **Figure 7.4**.

+ CONNECTION	– CONNECTION	RESULT
BASE	EMITTER	LOW RESISTANCE
EMITTER	BASE	HIGH RESISTANCE
BASE	COLLECTOR	LOW RESISTANCE
COLLECTOR	BASE	HIGH RESISTANCE
EMITTER	COLLECTOR	HIGH RESISTANCE
COLLECTOR	EMITTER	HIGH RESISTANCE

Figure 7.4. Resistance readings taken on a transistor. The + and – connections refer to true + and –; remember that the terminals are reversed when a multimeter is used on the resistance ranges

Figure 7.4 shows a pattern; the resistance between the collector and the emitter is always very high — too high for most meters to measure. Try it, but make sure that you aren't holding the leads, otherwise you will be measuring your own resistance, rather than the resistance of the transistor. The base and emitter connections behave like the terminals of a diode and so do the collector and base terminals. You might be forgiven for thinking

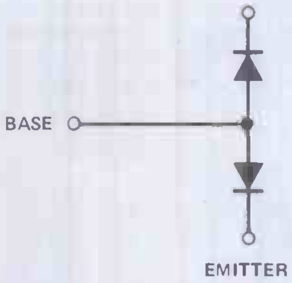


Figure 7.5. The results of resistance readings indicate that a transistor behaves like two back-to-back diodes — but only as far as resistance readings are concerned

that the transistor was just a couple of diodes arranged back-to-back as shown in **Figure 7.5**. You'd be wrong — as we'll see later — but as far as resistance measurements are concerned, using two terminals at a time, that is the way the transistor behaves.

We can even use a multimeter to find out which terminal on an unmarked transistor is the base. Just check the terminals two at a time, until you find a pair which don't conduct in either direction. The third terminal, the one that is not being used, is the base. The chart in **Figure 7.6** is a summary of this method for finding the base. You can't tell which of the other two terminals is the emitter and which the collector just by using a multimeter, but a transistor tester will soon show up the difference — we'll come to that later.

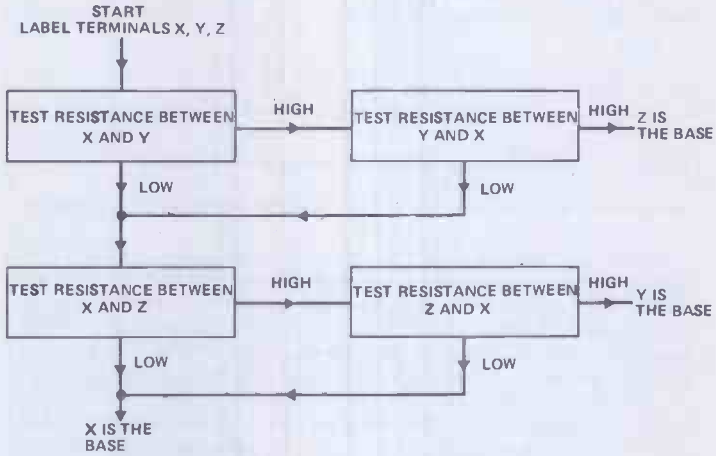


Figure 7.6. Base-finding chart for an unmarked transistor

Silicon Switching

Examining a transistor by using the resistance ranges of a multimeter might convince you that a transistor did not conduct between its collector and its emitter — and you'd be half-right. We can try this one out as a practical exercise using a cheap and easily obtainable silicon transistor such as the 2N697, 2N1711 or 2N3053. These all have the pattern of connections, which is shown in **Figure 7.7**, with the collector lead connected directly to the metal case. You have to be careful about this, making sure that when you use this type of transistor the case is not touching against any other component in the circuit — and definitely not against exposed wires.

I use this transistor type more than any other, because it is cheap and reliable and can dissipate a reasonable amount of power. Set up the transistor on the Eurobreadboard, using the lines shown in the diagram of **Figure 7.8**. This uses the **HE** meter as part of the collector circuit and, with the meter switched to the SMA range, it will be measuring the current through the collector.

Start with the 100k resistor, R- connected between lines A6 and Y1. This puts the base of the transistor at the same voltage as its emitter, so that no current passes between the base and the emitter. With this connection (assuming all is well) no current should be detectable on the **HE** meter because the junction between the collector and the base is reverse-biased (remember that this is an NPN transistor). A transistor in this state is said to be cut-off, meaning that no collector current is flowing, even though there is voltage between the collector and the emitter.

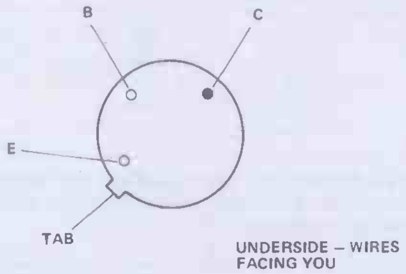


Figure 7.7. The TO-5 connection diagram used for the transistor types mentioned in the text

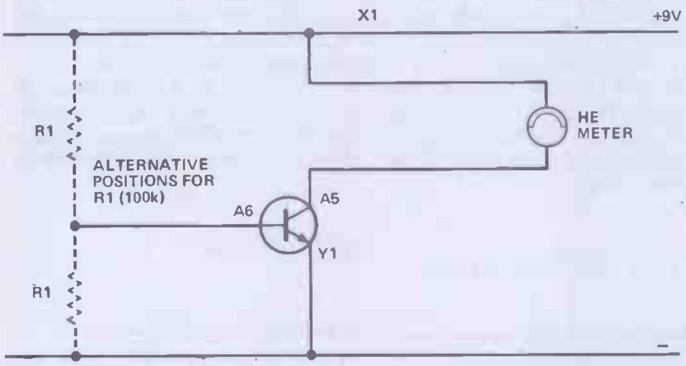


Figure 7.8. Investigating switching, using the HE meter

Now connect the 100k resistor, R1, between lines A6 and line X1. The base is now connected to the +9V line through the 100k resistor. Knowing about diodes, we should be able to guess what will happen now. Current will flow through the 100k resistor to the base and so through the base-emitter diode to the emitter. How much current? If the base-emitter part behaves like any other diode, there should be about 0.6 V across its terminals when it is conducting. Using a 9 V supply, that should leave 8.4 V across the 100k resistor. By Ohm's law (remember?), this should allow current of 8.4/100 mA to flow. That's not much of a current, only 0.084 mA, or 84 uA. Take a look, however, at the current through the collector that the HE meter is reading. How much is it? Several milliamps — I hope — (if the transistor is a good one) and that, in one brief example, is what a transistor does.

The transistor is a current amplifier. No matter how small the current between base and emitter, a much larger current will pass between the collector and the emitter. In fact, the collector current is proportional to the base current; if you double the current flowing between the base and the emitter, you will cause the current flowing between the collector and the emitter to also double. Halve the base current, and you will automatically halve the collector current. The ratio:

$$\frac{\text{collector current}}{\text{base current}}$$

is sometimes called the current gain (symbol h_{fe}) of the transistor, and it is an important quantity as far as using the transistor is concerned. Measuring the current gain gives us an idea of how good any transistor is, and transistor testers work on just this principle.

Figure 7.9 shows the circuit of a simple transistor tester for NPN transistors only. If you want to use it with PNP transistors, then you'll need a bit of additional switching. The idea is simple — we just pass a current between the base and the emitter, using a resistor to limit the current to a value which we can calculate, and we then measure the collector current that this causes. By using different resistor values we can test transistors which have very widely differing values of current gain.

Switch SW2 is the range switch and it should always be in position 'A' when the unit is first switched on with a transistor in place. If any current flows, now, then there's something wrong, because the transistor should not pass current when there is no current flowing in the base circuit. A transistor like this is 'leaky' and, because we can't control its collector current properly, it's of no use to us.

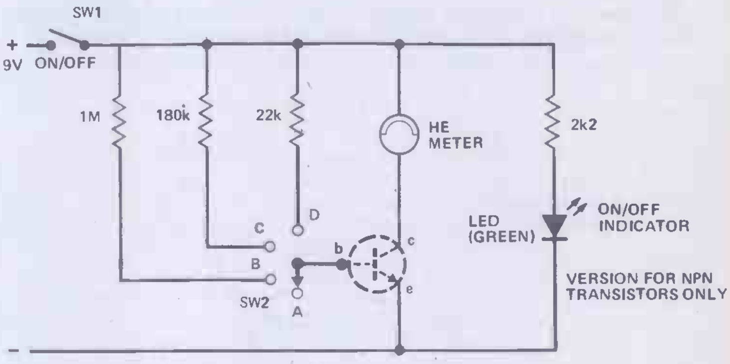


Figure 7.9. A simple tester circuit for NPN transistors. The meter can be built-in or sockets wired so that the HE meter can be plugged in

The next three positions of the switch SW2 allow different amounts to pass through the base of the transistor. Position 'B' of the switch passes about 8.6 uA through the base, so only a few transistors with a very large value of current gain, whose collector currents are several hundred times their base currents, will register much current on the meter in this setting of the switch. If the transistor gave no readable current in position 'A' of the switch but indicates several milliamps on the meter in position 'B', then the transistor is a really good one and no further testing is needed. If the current reading in position 'B' is low, try position 'C', in which the current to the base is now about 47 uA. A reasonable reading on the meter in this position indicates a reasonable transistor, a normal use-for-almost-anything chunk of silicon. If the transistor happens to be a power type and gives a good reading on this switch position, then it's a very good example of a power transistor. If the transistor is not a power type and it needs position 'D' of the switch to get a reasonable reading on the meter, then it's another candidate for the scrap heap. Note that power transistors are excepted. They normally have low values of current gain, so don't be surprised if you have to use switch position D for such transistors, particularly the physically large ones like 2N3055s.

The quantity that we call 'current gain' is usually listed under the heading h_{fe} in manufacturers, data sheets. This is a fancy abbreviation, but its meaning is the same. If you absolutely insist on knowing: h is short for **hybrid** parameter (meaning a set of quantities some of which are ratios like the current gain, others being resistances or conductances): f is for **forward** because we use the base as the input to the transistor and the collector as the output — we are measuring the effect of the input on the output, not the effect of the output on the input, so it's **forward** rather than backward; e means **common-emitter**, because both the base current and the collector current pass through the emitter — it's common to both circuits. So now you know — h_{fe} means the same as current gain and we can get figures anywhere from about 10 (for a power transistor) up to 1000 or more for some modern types of high-frequency transistors.

How do we make use of current gain figures? The main use is to calculate the currents that will flow in the transistor, knowing, or being able to calculate, just one value. For example, suppose that we want to pass 2.5 mA through the collector circuit of a transistor and we know that the current gain figure for that transistor is 150. This means that the collector current will be 150 times the base current (if there is no other resistance to affect it), so that the base current must be 1/150 of the collector current. 2.5 mA divided by 150 is 0.0166 mA, which is the same as 16.6 uA. Not a lot, really, but that's as much current as needs to flow to cause 2.5 mA in the collector of this transistor.

Now try it the other way round. Suppose we have a current of 25 uA in the base transistor and its current gain is 85; A current gain of 85 means that the collector current is 85 times the base current and 85 times 25 uA is 2125 uA, which is 2.125 mA. Easy, really!

Gathering MOS

The type of transistor which makes use of a PNP or NPN sandwich is called a 'bipolar' transistor and it's the type that you'll find in most of the projects in HE. There's another type of transistor, though, which uses a different sort of sandwich and it's called the field-effect transistor, or FET for short. FETs come in two types, the junction FET and the MOSFET; the MOS type is used mostly for integrated circuits and the junction type is used in circuits which also use bipolar transistors.

The important part of a FET is a strip of doped silicon which is called the 'channel', and which has a connection made to one end. Normally this channel has a fairly high resistance and the action of the FET depends on changing the resistance of the channel. If we make the resistance of the channel lower, then it can pass more current; if we make the resistance of the channel higher, then it will pass less current. The big difference between the two types of FET is the way that they control this resistance.. The junction FET has a junction formed on the channel; if the channel is N-type, then a chunk of P-type silicon is grown at one end of the channel (the 'source' end). A connection is made to the P-type layer and this connection is called the 'gate'. The other end of the channel is called the 'drain'.

Imagine, with the help of **Figure 7.10** that a junction FET has an N-type channel. This means that when a voltage is applied across the channel ends (between the source and the drain), electrons are passing between the ends. Now, because there is a junction, there will also be a depletion layer (remember?) which does not conduct. Putting a depletion layer into a channel is rather like taking one lane out of a motorway — it causes a jam, and it raises the resistance of the channel.

A depletion layer isn't fixed. If we reverse-bias the junction by making the voltage of the gate lower than the voltage of the source, the depletion layer becomes larger. This is like taking two lanes out of a motorway — there's a whole lot more resistance now. On the other hand if we forward-bias the junction, making the voltage on the gate more positive than the voltage on the source, then the depletion layer becomes smaller (all three lanes are open, but with speed restrictions!) and the resistance of the channel is less. We can therefore change the resistance of the channel by altering the voltage between the gate and the source. This is quite unlike the behaviour of a bipolar transistor.

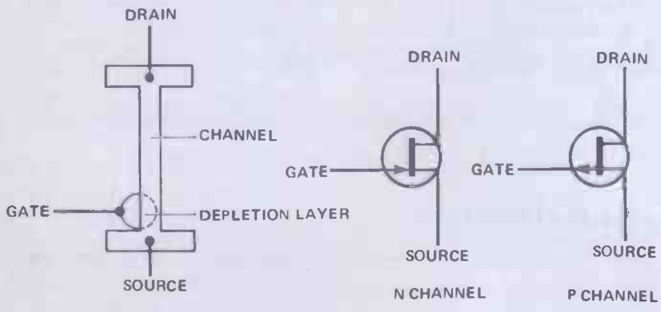


Figure 7.10. The action of the junction FET

The MOSFET contains no junctions, so that current can never pass between the gate and the channel. The channel is, once again, a strip of silicon which may be doped N or P and is formed on a chip which is oppositely doped and is called the substrate. The gate is made by forming a layer of insulating silicon oxide on the silicon of the channel, near the source end, and evaporating an aluminium strip on top of the silicon oxide, not touching the silicon of the channel (**Figure 7.11**). This sort of arrangement can also be used to make a capacitor. The action is straightforward — in fact, MOSFETs were being made experimentally around the same time as the first bipolar transistors. What happens is that when one plate of a capacitor is made positive (just for an example), then the other plate will also go positive until some charge flows. Similarly, if one plate is connected to a negative voltage, the other plate will also have the same negative voltage until some charge moves. One plate of the MOS capacitor is the gate, the other is the substrate.

Think, now, about a typical MOS arrangement as shown in **Figure 7.11** with the N-channel of semiconductor, that contains electrons which are free to move, and the substrate which contains free holes. If the metal gate of this transistor is connected to a positive voltage (more positive than the source) then the piece of channel which is just under the gate will also be at the same positive voltage. This will cause holes to be repelled away from the piece of channel just under the gate, thus making the channel wider and more conductive. If we make the gate of this N-channel MOSFET negative we can attract holes from the substrate, narrowing the channel and 'pinching-off' the conductivity. When the channel is 'pinched' between gate and substrate, the resistance of the channel rises. It is just as if the channel were depleted of electrons, so that this way of using a MOSFET is called 'depletion mode'. By making the MOSFET without any channel at all, and always keeping the gate voltage positive (for an N-channel MOSFET), a channel can actually be created, a method which is called 'enhancement'. The typical characteristics of an N-channel depletion mode MOSFET are shown in **Figure 7.12**.

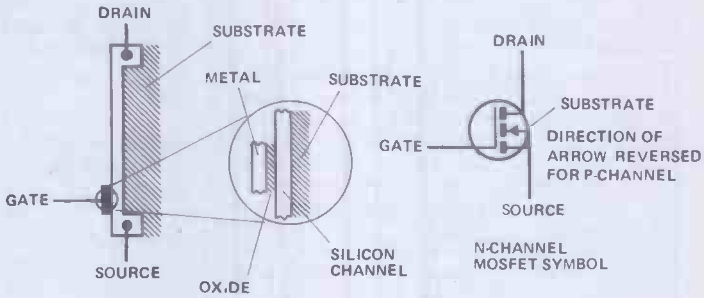


Figure 7.11. The arrangement of a MOSFET

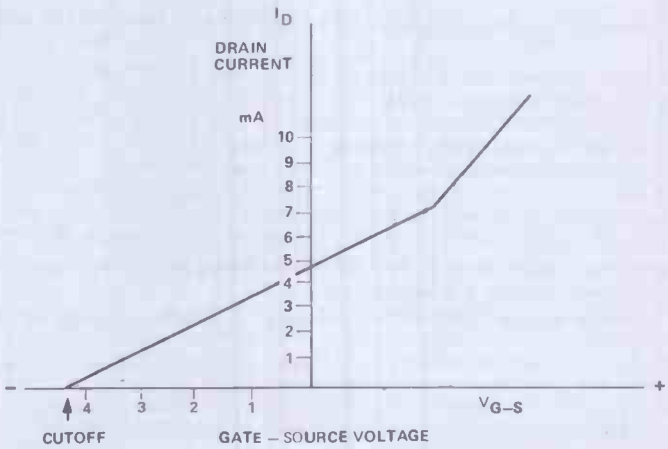


Figure 7.12. Characteristics of an N-channel depletion-mode MOSFET

Although the first ever transistor was, in fact, an FET type, the manufacturing processes available at the time were not suitable for the mass-production of reliable devices. Bi-polar transistors, however, could be easily made using what was a crude (by today's standards) but effective manufacturing method. The bi-polar transistor has thus become the main component for amplification in electronic circuits.

This month we have seen how this is possible: a small amount of current passing between the base and emitter of a bi-polar transistor will cause a much larger current to flow between emitter and collector. Next month we'll look at the transistor in more detail, considering some of the ways in which this current gain can be used to construct a practical amplifier. **HE**

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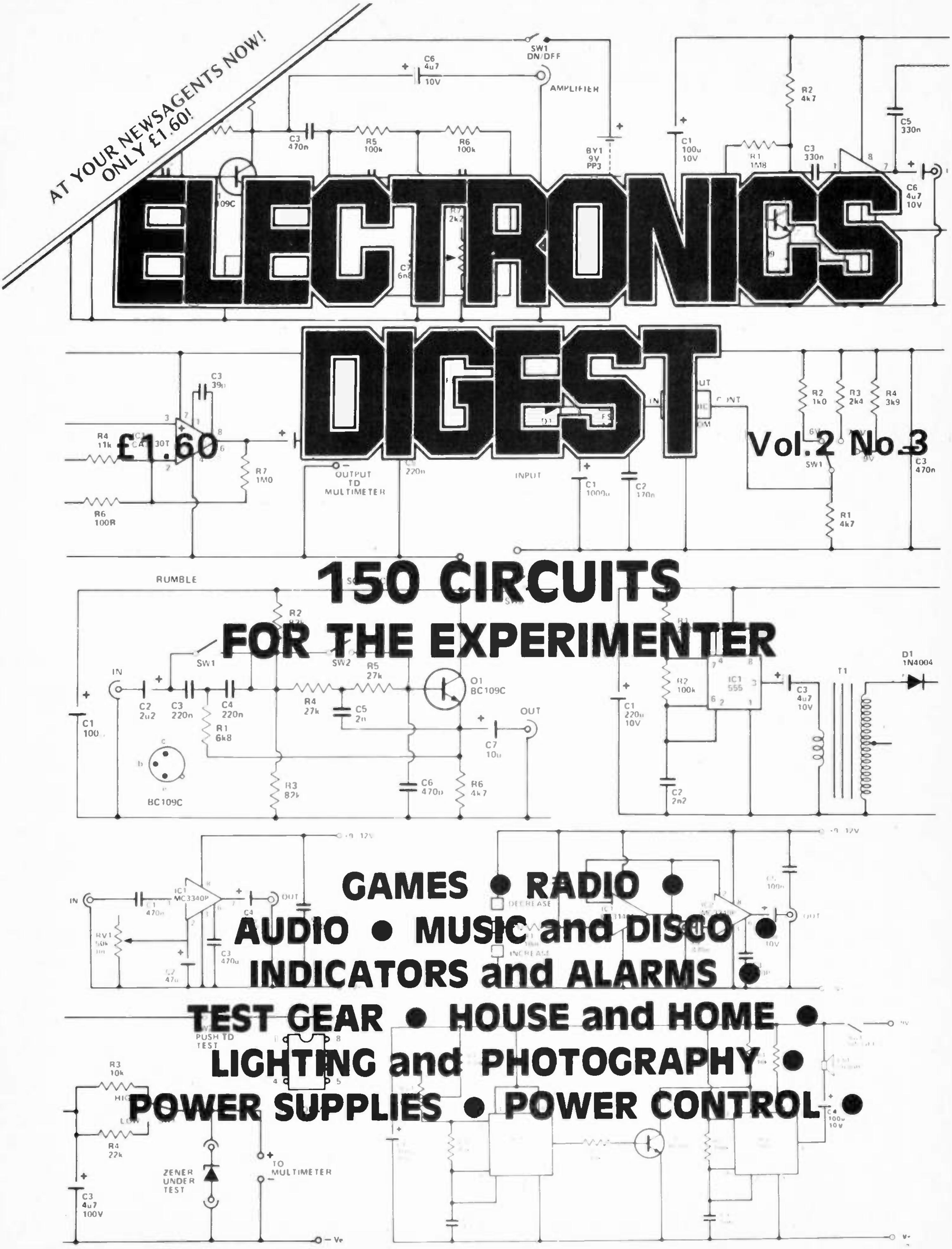
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A good joint is hard to find..

This might show you a thing or two about how to recognise the good, the bad and the indifferent among soldered joints.

SOLDERING IS somewhat of an art and is essential to the successful construction of electronic circuits. The beginner particularly *must* learn to solder correctly to achieve success and avoid frustration.

Components are supported by a variety of methods and connections rely on the soldered joint. The solder is not meant to provide mechanical support.

Solder

Solder is an alloy of tin and lead that melts at fairly low temperatures. A joint is made using solder as a filler and bonding agent. Soldering creates a continuous intimate contact between the solder and the metal surfaces by the mechanical interlocking of the solder with the irregular surface texture of the metals. This process is called 'wetting', as the solder flows onto and into the metal surfaces. The wetting of the metal surface by the solder is important in making a joint electrically and mechanically sound.

All metals oxidise, or tarnish, on the surface as a result of being exposed to air. This prevents the solder from wetting the metal surface, resulting in a poor joint; 'flux' is used to remove tarnish. For electronic work this is composed of resin (sometimes spelt rosin), which is obtained from the sap of pine trees plus additives called 'activators'. At soldering temperatures, the activators decompose, liberating an acid that dissolves the tarnish faster than pure resin. Other fluxes are also made for non-electronic uses, usually sheet-metal work, copper and brassware manufacture. These fluxes are usually highly corrosive (such as hydrochloric acid) and must *never* be

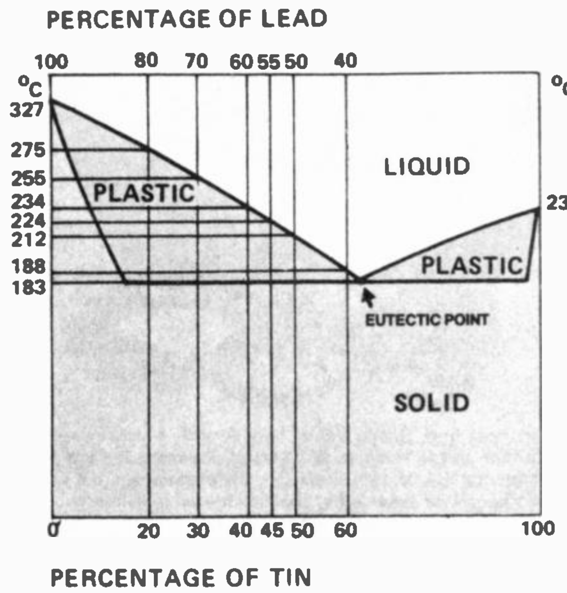

Fig. 1. How the melting temperature and plastic range are affected by the relative percentages of lead and tin in a solder alloy. At the 'eutectic point', an alloy of 63% tin and 37% lead goes from the liquid to the solid state at 183°C without going through a plastic phase. This makes it very brittle, and different contraction rates of the parts of the joint cause the solder to fracture. A small plastic range, such as for 60/40 solder, prevents this.

used for electronics work as even minute amounts rapidly corrode component leads and printed circuit board tracks.

Solder for electronics work is made as different gauge wires. Most have a resin core along their length, some have up to five separate cores.

The resin core melts before the solder and flows onto the joint, wetting both the joint and the solder, excluding the air. At the same time the activators dissolve the tarnish on the surface, allowing the solder to flow freely and properly wet the joint. When the solder melts, the increase in temperature deactivates the flux, limiting the possibility of corrosion. It is important to thoroughly heat activated resin during soldering to ensure the complete decomposition of the activators, otherwise they remain corrosive at normal temperatures.

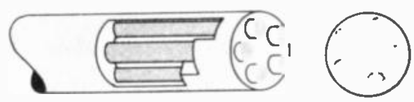

Fig. 2. Construction of a 5-core multicore solder. The flux cores are located near the surface so that they melt faster, giving rapid fluxing action.

Resin-cored solder is obtainable in a variety of wire gauges. For general and heavy work, such as on sockets, chassis, switch contacts, etc, 16 gauge is suitable. For fine work on printed circuit boards, miniature components, etc, 20 or 22 gauge is best. It pays to have several different gauges handy. Experience will show which is the best under different circumstances.

As already mentioned, solder is an alloy of tin and lead. Tin melts at 327°C and is plastic down to 283°C. Lead melts at 232°C and is plastic from 183°C to 232°C. Either by itself is unsuitable as any movement of the joint while the soldering metal is in its plastic state will result in a faulty joint. An alloy of appropriate proportions has a plastic state temperature range that is much smaller, and a lower melting point (see **Fig.** 1). With a composition of 63% tin and 37% lead, the alloy has *no* plastic region. It goes from solid to liquid at exactly 183°C. This is undesirable as a small region of plasticity reduces brittleness under practical circumstances. The most common composition of solder for electronics work is therefore 60% tin — 40% lead, often called 60/40 solder. It melts at a temperature of 188°C and has a plastic range of about 5°C. It combines optimum strength with lowest electrical resistance. Another type of solder used in electronics work includes about 1.5% copper and is known under the trade name of Savbit. Soldering irons with copper tips corrode rapidly when used with straight 60/40 solder as some of the copper is absorbed into the molten solder. Savbit solder prevents this and can extend the life of copper bit soldering irons by up to ten times. Some soldering tools have iron-plated tips to reduce this sort of wear and the use of Savbit is not necessary with these irons.

Ordinary solders, such as 60/40 solder, are also referred to as 'soft solder'. Joints that have to withstand high temperatures, or that need greater mechanical strength than obtained with 60/40 solder, are joined with 'hard' solders that melt at higher temperatures. Hard solder contains either 30/70 or 20/80 tin-lead and melts at 255°C and 275°C respectively.

'Silver' solder, containing 5% tin/93.5% lead/1.5% silver, melts at about 300°C and is mostly used in fabricating brass or copper chassis, etc. Silver solder is usually melted with a gas-burning torch. A special flux is also used.

Low-temperature solder is also obtainable and is used where components may be damaged or where it is necessary to solder onto a joint that is already soldered without melting the existing joint. This has most applications in special servicing jobs. It consists of 50% tin/33% lead/17% cadmium and melts at 145°C. It requires care in soldering as it tends to fracture the instant it solidifies.

Soldering Irons

It is important to select a suitable soldering iron — after all, it will probably be the tool you use the most! A bewildering variety of types and sizes are available.

Continuous Heat Irons

These are probably the most widely used despite a few drawbacks. They are heated by a wire resistance element located in the barrel just behind the tip. The most suitable rating for electronics work is between 15 and 30 watts. Tools below this rating generally do not have sufficient heat capacity, while those above have high tip temperatures that can result in damaged components and poor joints. Irons of the continuous heat type that have ratings above 80 watts are best for sheet metal work. Irons advertised as 'universal' (mostly having a rating of 40 or 50 watts) should be avoided as they are usually too bulky for electronics work, particularly on printed circuit boards, and have too much heat capacity and high tip temperatures with the likelihood of component damage. The handle also usually gets too hot for comfort.

Choose an iron which is comfortable to hold. As well as being light, the iron should preferably have a lightweight power cord to reduce drag on your wrist when moving the iron around. The length of the cord should be adequate — about 1.5 m to 2 m is a good length.

Continuous heat irons are slow to heat to soldering temperatures — they are usually left running continuously. This causes tip oxidisation which therefore requires constant maintenance and fairly frequent replacement. These are minor drawbacks, however, if you cannot afford a more expensive iron.

Some irons of this type are obtainable with a temperature select switch in the handle. This usually doubles the power when needed to provide sufficient heat to make the occasional heavy joint. They are normally used on the lower power position for routine soldering.

Quick Heat Irons

These irons operate from a low voltage at a high current, usually supplied from a transformer, and take only a few seconds to reach soldering temperature. They take only a few more seconds to reach red heat if the operating button is held on too long!

Quick heat irons are made in two basic styles — the soldering gun and the low-voltage iron.

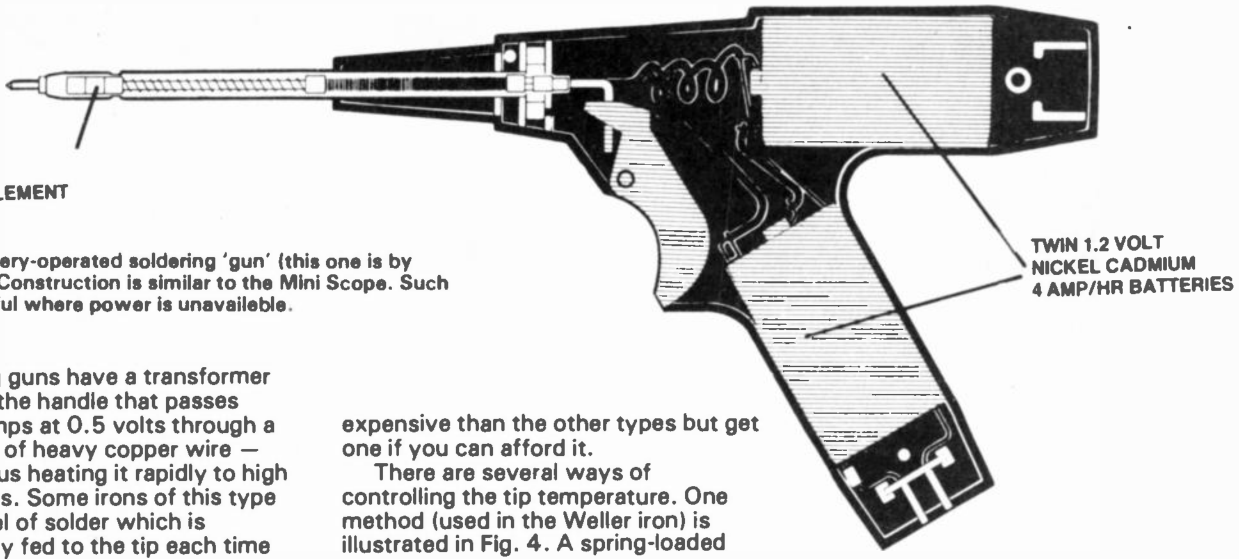

Fig. 3. A battery-operated soldering 'gun' (this one is by Scope, too). Construction is similar to the Mini Scope. Such irons are useful where power is unavailable.

Soldering guns have a transformer mounted in the handle that passes about 50 amps at 0.5 volts through a short length of heavy copper wire — the bit — thus heating it rapidly to high temperatures. Some irons of this type include a reel of solder which is automatically fed to the tip each time the trigger is pressed — but for good joints that's not where you want the solder; it needs to be applied to the joint.

Low-voltage irons have a push-ring or lever on the handle which pushes a carbon contact against the rear of the tip, passing a current of about 30 amps at 3 volts. The contact, having a higher resistance than the rest of the circuit, rapidly heats up, passing its heat to the tip, which reaches soldering temperature in a few seconds. An external transformer supply is the necessary power.

Quick heat irons are suitable for intermittent handyman use or applications requiring their large heating capacity. They are not recommended for general electronics use, particularly on printed circuit boards. They require some skill to control the heat so as not to damage components by overheating. Some do not have an electrostatic screen on the transformer, and ICs and some transistor (particularly MOSFETs) can be damaged by leakage currents.

Despite their limitations, quick heat irons can be useful in an electronics workshop. If you contemplate purchasing one make sure the transformer has an electrostatic screen.

Soldering guns have the disadvantage that the transformer in the handle tends to make them a little unwieldy, especially for prolonged use.

Battery-operated soldering irons have become widely available, and these find application where power is unavailable or inconvenient to supply. These irons can be used where components sensitive to leakage currents (ie MOS devices, CMOS ICs, etc.) are employed. Rechargeable batteries, usually contained in the handle, supply the current. They are not suitable for prolonged use.

Temperature-Controlled Irons

Temperature-controlled irons are made specifically for electronics work. They are unsurpassed for good soldering, convenience and minimum possible damage to components. They are more expensive than the other types but get one if you can afford it.

There are several ways of controlling the tip temperature. One method (used in the Weller iron) is illustrated in Fig. 4. A spring-loaded switch within the handle is operated by a magnet and temperature-sensitive sensor assembly located in the barrel. The temperature-sensing element consists of a ferro-magnetic material, which at a certain temperature (called the Curie point temperature), loses all magnetic properties. The actual Curie point temperature depends on the composition of the ferromagnetic material. The Curie point for iron is typically 1000°K, 633°K for nickel and 1393°K for cobalt. An alloy of these and other ferromagnetic materials can be selected to produce any temperature required.

When the tip is cold the magnet is attracted to the sensor, which actuates the switch, applies power to the element, and heats the tip. When the tip reaches the Curie point temperature the sensor releases the magnet, opening the switch and removing power from the heating element. When the tip cools slightly, the magnet is again attracted to the sensor and the whole cycle is repeated, maintaining the tip within a few degrees of the selected temperature. The iron can be heard to emit a small click as the magnet goes through its attract-release cycle.

The tips are removable and sensors having different Curie point temperatures are available. One can select tip temperatures in the range 260°C to 430°C. A variety of shapes is also available to suit different applications. The Weller irons operate from a 24 volt transformer which is moulded into the stand supplied.

Another type of controlled-temperature iron has circuitry in the stand supplied with it which monitors the tip temperature and controls the supply to the heating element, thus maintaining a constant tip temperature. In this type, a control knob is provided in the stand which allows the operator to set the desired tip temperature (**Fig. 7**).

Where 60/40 solder is used for construction work, a tip temperature of 250°C (500°F) is recommended. This is sufficiently above the melting point of 215°C to allow for heat conducted away by the joint and still melt the solder. If using Savbit solder, it melts at a slightly higher temperature and a tip rated at 275°C (550°F) is recommended.

For desoldering, such as in servicing work, a tip temperature of 315°C (600°F) or more is necessary; up to 370°C (700°F) is recommended where large connections are involved.

Soldering Bits

The soldering iron bit conducts heat from the iron's element to the joint. A typical bit is shown in Fig. 6.

The tip temperature and the amount

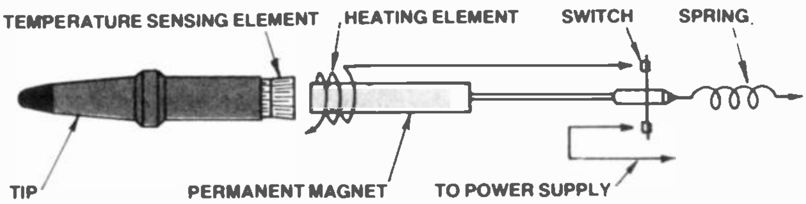

Fig. 4. Temperature control system that exploits the 'Curie point temperature' of a magnet to turn the power on and off to the heating element. The magnet is attracted to the rear of the tip, closing the switch. The element heats the tip and when the temperature reaches the Curie point of the magnet, the magnet loses its magnetism and the spring opens the switch. When the temperature drops below the Curie point, the cycle is repeated. Some models of the Weller soldering irons employ this technique of temperature control.

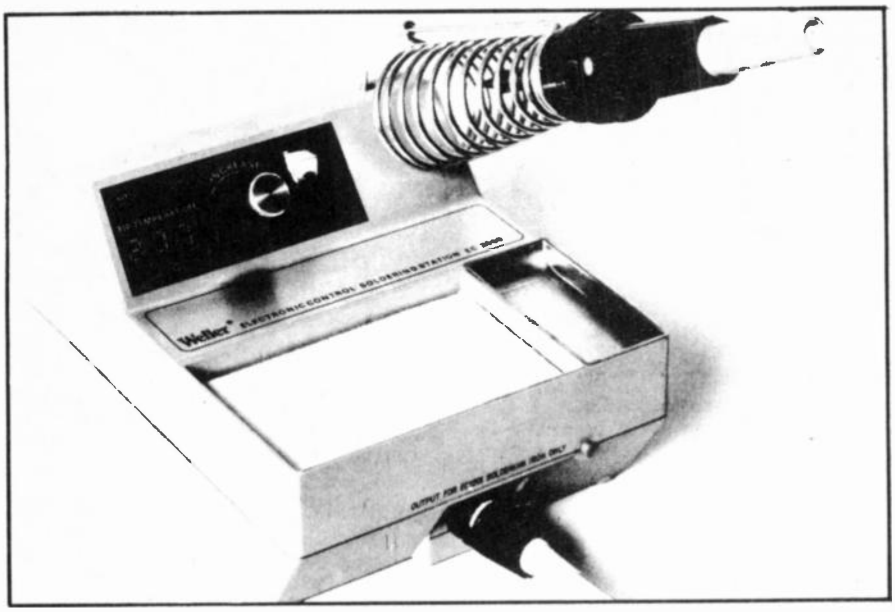

Fig. 5. This iron, Weller's model EC2000D, employs a temperature sensor in the tip and electronic control of the power to the heating element to maintain the tip temperature within very close limits. The desired temperature is set by a knob and displayed in the three-digit readout.

of heat it stores are important factors in obtaining a good soldered joint. The tip temperature will drop when making a joint due to heat being conducted away by the parts of the joint. Just how much the temperature drops and how fast depends on the capacity of the bit to store heat and the mass of the parts being joined. The larger the bit, the more heat it will store and transfer to a joint, and the les will be the temperature drop. Temperature-controlled irons minimise these problems to a large extent.

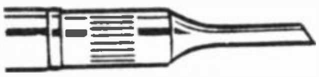

Fig. 6. A typical replaceable soldering iron bit. This one screws onto the end of the iron barrel, and the cylindrical tip has a 'flat' on the end at an angle of about 60° to the axis.

For an adequately rated iron, the correct bit for the job will remain above soldering temperature (without burning the joint) and cause the solder to flow properly. If the tip is too small, too much heat will be conducted away, and the solder, while it may melt a little initially, will not melt and flow properly and a poor joint results. The effect of proper bit size is shown in Fig. 7.

Bits are usually made of copper, copper alloy or iron-plated copper. A plated bit is shown in Fig. 8.

Unplated bits transfer heat more effectively but oxidise rapidly, reducing their efficiency. Their life is much shorter than plated bits and they require more frequent maintenance.

The area of the tip face determines the rate of heat transferred to the joint. A small area will have a higher temperature but less heat reserve (or

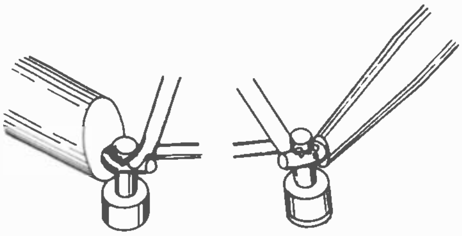

Fig. 7. The bit should be large enough for the job, otherwise too much heat is conducted away from it by the joint and the solder will not flow properly. The bit on the left is OK, that on the right is too small.

capacity) than a large tip. Generally, the more heat the work is likely to absorb, the larger the tip area should be. However, the area should not be so large that it obscures the work or damages adjacent parts.

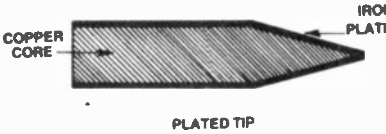

Fig. 8. Plated bits last longer because they do not oxidise as rapidly as unplated bits. They are usually iron-plated.

The distance the bit protrudes from the barrel of the iron is also important. The shorter this distance, the higher the tip temperature. Usually, it is best to select a bit length as short as practicable to reduce the heat path from the element to the tip, and to minimise wobble and bending of the bit. It should not be so short that the barrel touches or radiates onto nearby components or that the tip temperature becomes too high. One way of reducing the temperature of a small-diameter bit is to increase the length beyond that used for the larger-sized bit — or vice versa. Bent bits can be used in awkward places where a straight bit cannot reach.

Maintaining The Iron And Bit

For maximum efficiency and consistently good joints, the soldering iron and bit require frequent but simple maintenance. Heating produces oxidisation of the barrel and bit, the oxide forming a scale on the parts. This reduces heat transfer as the scale is an insulator. Continuous heat irons are particularly affected. Excessive scaling is produced by high operating temperatures and by prolonged use without descaling.

To remove scale, remove the bit and tap both the barrel and bit firmly on the bench top. This should be done regularly. Only remove a plated bit from the barrel of an iron when it is quite cold.

For efficient transfer of heat from the bit to the work, the face of the bit should be smooth and coated with a shiny layer of resin-free solder. A bit in this condition is said to be 'tinned'. A clean, new bit is tinned by heating it to soldering temperature (test it by lightly touching solder on the face of the bit) and applying a small amount of solder to the face and letting it flow freely to cover the face. Any excess should be removed by wiping it on a lightly damped sponge or cloth.

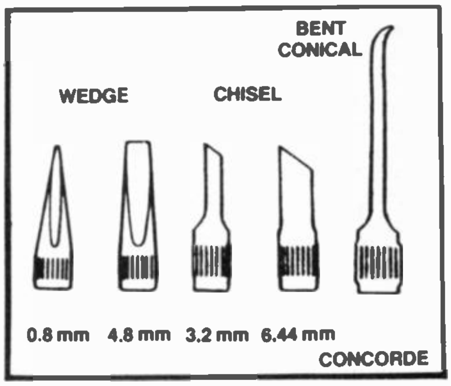

Fig. 9. Bits can be obtained in a variety of shapes to suit the job, such as conical, wedge, bevel, chisel, etc. The most common bit shapes are the wedge (or chisel) and the bevel. They can be different diameters and lengths, giving different heat capacities.

With use, the face of the bit becomes pitted and the solder layer takes on a dull grey appearance. During soldering, some of the copper from the face is absorbed into the solder and with repeated use the surface becomes uneen. There is less absorption with plated tips. Copper bits in good condition and in bad condition are illustrated in Fig. 10. The 'pitting' can be removed by filing. Only file off as much as necessary to produce a smooth face again. Excessive filing reduces the heat capacity and increases the bit temperature. Remove any scaling as well. When a clean tip is obtained, re-tin the face. Do not pull the tip further out from the barrel to compensate for reduced length as this overheats that section of the heating element not in contact with the bit, producing excessive scaling and eventually causing the element to fail.

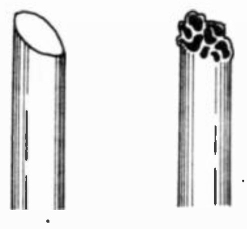

Fig. 10. The tip should be in good condition, as at left, for good soldering, not worn, pitted or oxidised as at right.

Small surface irregularities on plated tips should be repaired with fine emery cloth when the tip is cold. Take care not to remove the plating. After cleaning, heat the bit and re-tin the face. Relatively large pitting on a plated bit means that some plating has come off. Attempts to remedy the situation usually result in more plating being removed. In such cases, replace the bit.

During normal soldering with a plated bit, the molten solder on the face should be replenished regularly while the tip is hot. The face can be cleaned by wiping it on a damp, fine-textured sponge (these are usually supplied with controlled temperature irons). Do not overdo it or you will remove all the molten solder. Wait a few seconds after wiping the bit to allow it to recover heat and then lightly re-tin the face. Plated bits should have a small amount of excess solder on the face while not being used.

With either plated or unplated bits, regular cleaning during use is a good practice, making soldering easier and ensuring good joints. A damp sponge pad is good for either type of bit. A fine textured wire brush may also be useful with copper bits. (Fig. 11.)

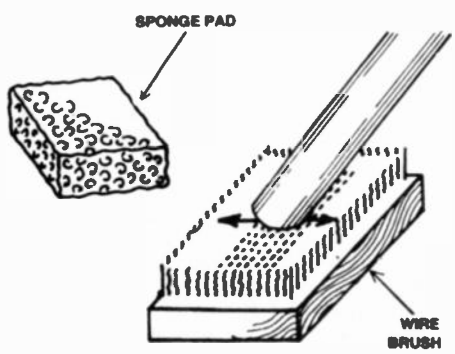

Fig. 11. The tip should be cleaned regularly during use. A moist sponge pad (left) is good for frequent wiping, while for unplated tips an occasional scrub on a wire brush keeps the tip in good condition.

Soon after learning soldering, most people will use one of two methods to remove excess solder from the bit: viz: *flicking* or *wiping*. Wiping is the recommended method. Flicking causes blobs of molten solder to splatter on to all sorts of awkward places. If you're a flicker, don't wear shorts! Apart from ruining the carpet and prompting sudden leaps into the air, molten blobs of solder have a nasty habit of getting into equipment and causing short circuits — which may be disastrous. For habitual flickers, either cure yourself of the habit or screw a low, open-topped container to the bench top and aim in there from close quarters. It is even possible to recycle the solder thus collected — but not in your project.

Basic Soldering

Before use, the soldering iron should be turned on for long enough to allow the bit to reach soldering temperature. Irons vary quite a bit in this; some take quite a few minutes to warm up, whereas others are much quicker. The parts to be joined should be bright and clean; if not they should first be tinned (see 'Preparing Leads and Components').

When the parts to be joined are prepared, and with the iron at the correct temperature, apply the face of the bit to that part of the joint having the greatest mass (providing it isn't the most heat sensitive). Allow the joint to heat for a few seconds to raise it to soldering temperature, and then apply a little solder. If the parts are clean, the solder will flow freely as it melts, wetting the joint properly and making a smooth, shiny joint. Remember that the solder must be applied to the joint and *not* to the iron.

Figure 12 shows how to solder a component lead to a tag. Apply the iron to the tag as the tag has the greatest mass. To improve heat transfer and reduce soldering time, first apply a little solder to the iron at the junction of the bit and the tag. Just a touch is sufficient. The flux removes any tarnish from the tag and the hot solder

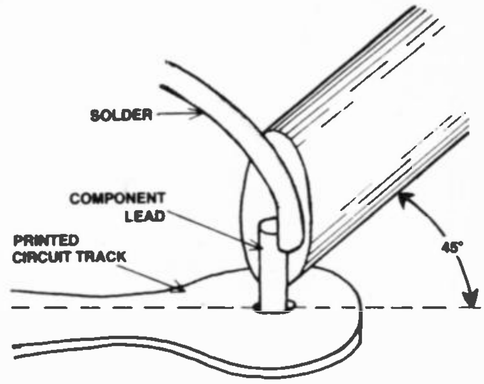

Fig. 13. When soldering a component lead to a printed circuit board, apply the iron to the lead with the tip touching the copper track as well.

tarnish that forms on the face of the bit, allowing rapid heating of a small area. The molten solder improves the thermal contact by wetting both surfaces and filling the minute air spaces between them. Next apply the solder to the tag. The solder will only melt if the tag is at the correct temperature, thus ensuring proper wetting.

Soldering components to a printed circuit board is shown in Fig. 13. Always take care not to overheat printed circuit boards as the copper track may lift, damaging the board and making subsequent connections difficult.

Always hold the iron on the joint for a second longer after sufficient solder has been applied. This ensures that all the solder is melted and that the flux has been de-activated. Allow the solder to cool naturally. Don't blow on it to cool it. Don't move the joint while the solder is solidifying — a poor joint may result.

Take care not to apply too much solder as it may conceal a poor joint. On printed circuit boards, too much solder may cause 'solder bridges' to form between tracks.

How much is the right amount of solder, and what does a good joint look like?

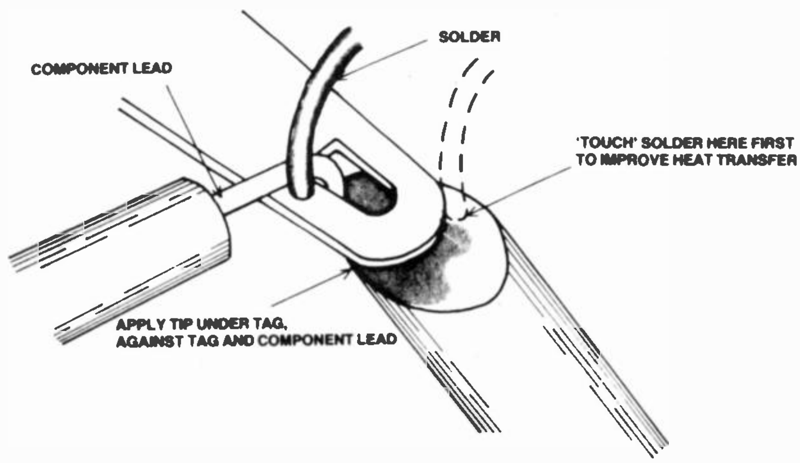

Fig. 12. When soldering a component to a tag, apply the iron to the tag *and* the lead to heat them up. After a few seconds, touch the solder on the iron *briefly* and then apply the solder to the join.

The size of the solder 'fillet' should be large enough to fill the area of the joint and the contours of the parts should be plainly visible. The surface of the solder should be smooth and bright and meet the parts of the joints at a tangent. This 'feathering' indicates good wetting. The characteristics of a good joint are shown in **Fig. 14**.

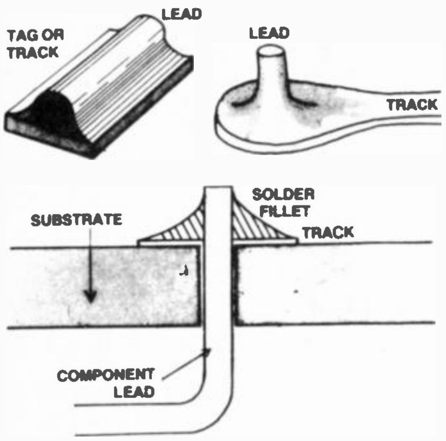

Fig. 14. A good joint will be covered by a small fillet of solder which meets the parts of the joint at a tangent. The solder should be smooth and bright.

There must be sufficient solder filling the spaces of the joint to ensure a good mechanical bond. Insufficient solder results in a mechanically weak joint. The joint is likely to go open circuit or intermittent under slight mechanical stress (such as due to vibration or expansion and contraction with temperature changes). Joints having insufficient solder are shown in **Fig. 15**.

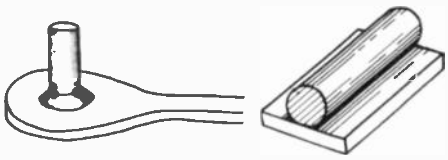

Fig. 15. Insufficient solder leads to a weak joint which may become faulty.

The Problem Of Plated-Through Holes

Double-sided PCBs with plated-through holes are becoming increasingly common. It is important that the correct technique be used to solder components to the board as well as when desoldering component leads.

In general, one can solder component leads from the *component* side of the board. The usual rules, as described here, about applying the iron to the lead and the track apply. Likewise with the appearance of the joint. Component leads should not be crimped or clinched as it is unnecessary. A properly made joint is illustrated in **Fig. 16**. The application of too little solder will result in a joint as illustrated in **Fig. 17**.

When desoldering leads from a through-plated hole, as much solder should be removed from the joint as possible. Vacuum-operated desoldering tools are best for this purpose. However, the lead should be removed while the iron is still applied to the joint and the solder is molten. Otherwise, you may damage the through-plating in the hole. The iron should not be pressed hard onto the pad as this too can result in damage to the through-plating. With ICs and/or IC sockets where a number of joints have to be desoldered simultaneously, special desoldering tool bits can be obtained, or else the pins of the package must be cut, destroying it.

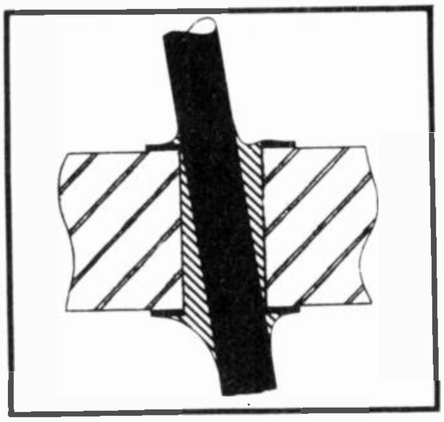

Fig. 16 A properly made joint in a plated-through hole.

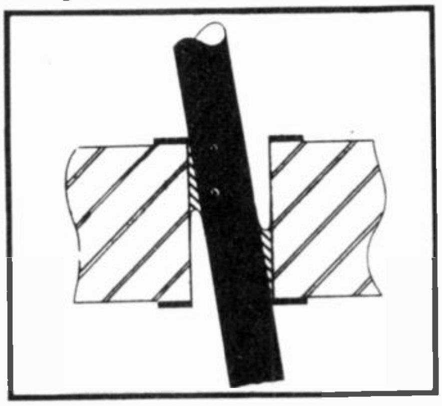

Fig. 17 Too little solder results in weak joint that may fracture and become intermittent or unreliable. When desoldering, a little solder will always adhere to the joint inside the hole in the positions shown, so the lead must be withdrawn while the solder is molten.

Bad Joints And How To Cure Them

In some instances, the solder may not wet the joint evenly. The solder surface is not smooth and continuous, having irregular, round, non-wetted areas exposed. The solder may meet one surface abruptly in places. This condition is illustrated in **Fig. 19**. It can often be remedied by reheating, although desoldering and cleaning may be necessary in some cases.

When a joint is not wetted at all, usually due to tarnish, the solder will not completely cover the surface and appears as droplets or balls (**Fig. 20**). This is a bad joint mechanically and electrically and should be taken apart and properly prepared.

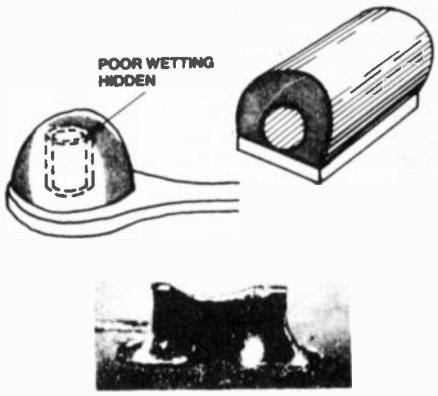

Fig. 18. Too much solder can hide poorly wetted surfaces (top left), which results in a poor joint. On PCBs with close conductor spacing too much solder leads to 'bridging' (bottom).

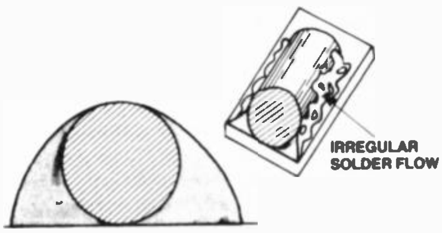

Fig. 19. When poor wetting occurs, the solder meets one surface at an abrupt angle and the solder flows irregularly.

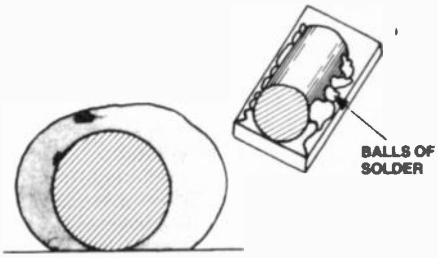

Fig. 20. Tarnished surfaces prevent wetting altogether. Ball of solder sit on the surface.

Sometimes during soldering, the molten solder will run along the metal and then withdraw towards the fillet when the iron is removed (**Fig. 21**).

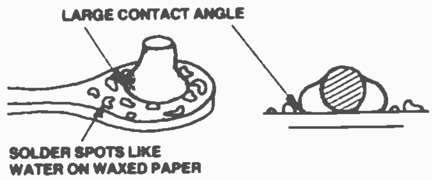

Fig. 21. Dewetting. The solder appears to flow properly, then withdraws when the iron is removed from the joint.

This 'dewetting' is another problem caused by tarnish that the flux is unable to remove. The joint has to be desoldered and thoroughly cleaned before resoldering. Applying more heat and excess solder may make the joint look all right but it may conceal a bad joint.

A 'cold' or 'dry' joint is usually caused by movement of the parts during soldering or as the solder is solidifying. It is also caused by the solder running onto surfaces cooler than the soldering temperature. A cold joint has a frosty appearance, as shown in **Fig. 22**, but may otherwise look like a good joint. The trap with cold joints is that they may perform quite well for a considerable period and then suddenly become intermittent or go open circuit. They are repaired quite simply by reapplying heat or desoldering the joint and then resoldering.

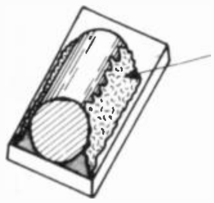

Fig. 22. A 'cold' joint. The solder surface has a frosty appearance but looks good otherwise.

If insufficient heat is applied to a joint, the solder solidifies before adequate wetting occurs, causing the angle of contact between the solder and the parts to be very large. The flux is not properly activated and the joint may tarnish. The solder can usually be pried loose. The surface of the solder may be smooth and continuous but it is not attached to the parts of the joint (**Fig. 23**). Reheat the joint if tarnishing is not evident, otherwise desolder and clean before soldering.

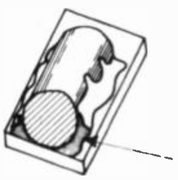

Fig. 23. Too little heat. The solder forms a large contact angle with the surface and can be prised loose.

In some cases, a resin bond is formed between the parts of a joint. In this case, the angle of contact of the solder is usually large and a layer of solidified resin forms the bond, as shown in **Fig. 24**. There may be no electrical contact at all, the joint has little strength and may be prised apart. It may be caused by excess flux or solder running onto surfaces cooler than soldering temperature but hot enough to melt the flux. It is usually cured by reheating the joint, making

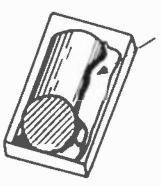

Fig. 24. A resin bond. There may be no electrical contact at all. It can be cured by reheating the joint.

sure that all parts are brought up to soldering temperature.

When soldering multi-strand hookup wire, excess solder or long soldering time can cause solder to run along the strands. This is called 'wicking' (**Fig. 25**) and can be reduced by soldering faster or by using a heatsink on the wire. Wicking makes the wire brittle and liable to break when it is moved.

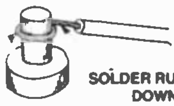

Fig. 25. 'Wicking' is caused by solder running back up multistrand hookup wire. This makes the wire brittle at the joint and movement may break it.

When the soldering iron is withdrawn from a joint a spike of solder, called an 'icicle', is sometimes left behind, usually pointing in the direction in which the iron was removed (see **Fig. 26**). Icicles may be caused by a variety of problems, including tarnished joints, too short soldering time, low soldering temperature or excess solder on the iron. Reapplication of the soldering iron usually remedies the problem, but make sure that there is not some other problem with the joint. If the joint is otherwise sound, small icicles are nothing to worry about.

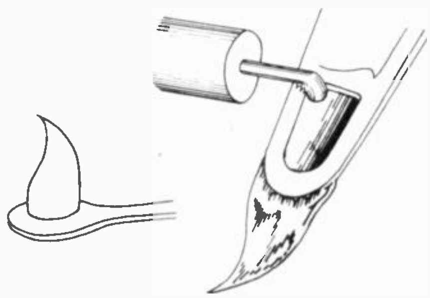

Fig. 26. 'Icicles' sometimes form on a joint when you remove the iron. Reheat the joint with a clean tip to get rid of them.

Preparing Leads And Components

Most modern components have leads which are tin-plated to aid soldering. The tin is readily absorbed into the solder, allowing rapid wetting and reducing soldering time. The plating will tarnish with time and handling. Unplated leads and unprotected printed circuit boards are particularly affected as oxidisation is quite rapid.

It is always a good practice to tin the parts of a joint before puttig them together. Component leads can be tinned by simply heating them with the iron and then applying a little solder. Only tin that part of the lead that is actually going to make the joint as component leads are usually trimmed after the joint is made. If the lead is tarnished, it can be cleaned by pulling it through a doubled-over piece of emery cloth or plain steel wool. Printed circuit board tracks do not need tinning. If the tracks are tarnished, clean the board with an abrasive powder cleanser (such as Ajax) and a moist cloth. Wash the board in clean water after cleaning and dry with a tissue or paper towel.

Stranded hookup wire is best prepared in the following manner. Strip away about 6-7 mm of insulation from each end. Twist the strands together, apply the hot iron for about one second and then a touch of solder. Don't overheat or apply too much solder. Solid hookup wire is prepared the same way as component leads.

Tarnished tags are best cleaned by rubbing with emery cloth or lightly scraping them with a penknife. Thoroughly heat the tag with the iron before applying a little solder to tin it.

Enamelled coil wire can be prepared by stripping the end back about 6-10 mm using a penknife, cutting blade, emery cloth or steel wool until the bright copper wire shows. Tin it quickly. Some modern coil winding wire is coated with an enamel that, although very tough, melts at soldering temperatures ('Bicalex' and 'Lewmex' are several trade names). A hot soldering iron is applied to the end to heat it first. Apply some solder to the face of the iron then to form a molten blob to cover the wire. Shortly, the insulation will smoke and burn off, allowing the wire to be tinned. A good hot tip is necessary for this operation.

Mounting Components On Terminals

There are good and bad ways of attaching component leads to terminals before soldering. The correct method of attachment depends on the type of terminal. Pins are generally meant to have the lead bent around them, other terminals have holes through which the component lead is inserted. The main principle to keep in mind is that the lead must always be easy to remove if subsequent servicing or modification is necessary. Also, the solder should not provide all the mechanical support for the component.

Terminal Pins are often used with matrix board, being inserted into the holes at convenient positions. The component lead should be bent around the pin, making an angle of approximately 135°, as shown in **Fig. 27 (left)**. If the angle is too small, the connection is mechanically weak — it depends too much on the solder. If the

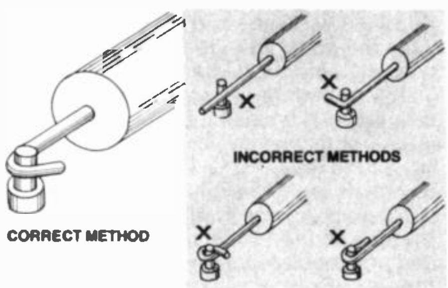

Fig. 27. How to attach a component lead to a terminal pin before soldering.

lead is wrapped right around the terminal it is difficult to remove (**Fig. 27, right**).

When mounting a component between two terminal pins, first bend each lead at the point corresponding to the position of the terminal, leaving sufficient slack in each lead for a little movement in the component. Tension each lead against the terminal during soldering (**Fig. 28**).

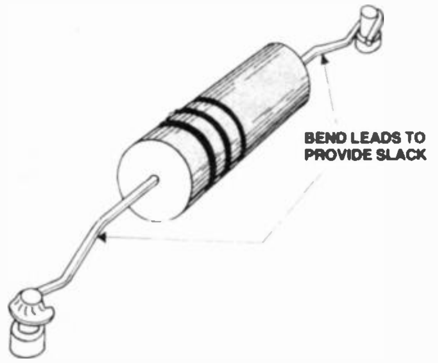

Fig. 28. When mounting a component between terminal pins leave a little slack in the leads.

Solder Tags and Terminals with Holes are found on tagstrips, potentiometers, switches, etc. The best methods of connecting leads to them are shown in **Fig. 29a**. In each case, there is adequate contact between the lead and terminal and the lead can be easily removed if necessary later. Do not wrap the component lead right around the terminal as this makes subsequent removal difficult and messy, but if the lead is not bent around the terminal at all too much dependence is placed on the solder for both mechanical and electrical connection. The *wrong* ways are illustrated in **Fig. 29b**.

The way a component is mounted *between* two terminals of this type depends on the orientation of the terminals. Where the holes are approximately parallel, bend each lead at right angles at the point corresponding to the position of the terminal hole. The lead is inserted without further bending (**Fig. 30**). Leave a little slack in the leads for movement. Hold the lead firmly when soldering.

Where the terminal holes are in line (ie coaxial), bend one lead around one terminals as illustrated in **Fig. 29** and pass the other lead through the other terminal without bending it. Solder the bent lead first. Tension it against the terminal while soldering. Arrange a little slack in the leads before soldering the remaining lead (**Fig. 31a**). If the terminals are at a slight angle to one another, form one lead to pass along the side of the terminal closest to the body of the component before entering the hole. Don't bend it further. Pass the other lead through the other terminal hole without bending it either. Solder the bent lead first, tensioning it against the terminal to prevent movement. Again arrange a little slack in the leads before soldering the remaining lead. (**Fig. 31b**).

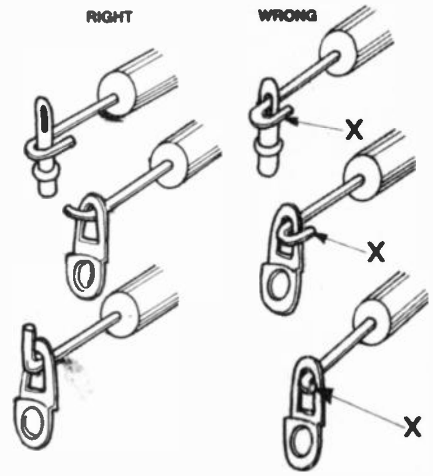

Fig. 29. The best way to attach component leads to tags and terminals (left).

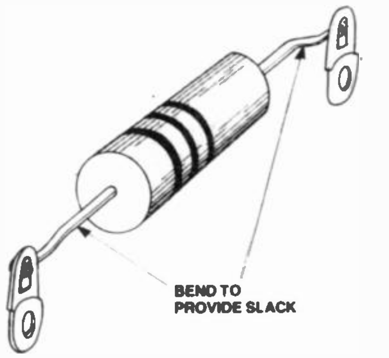

Fig. 30. Mounting a component between tags with parallel holes.

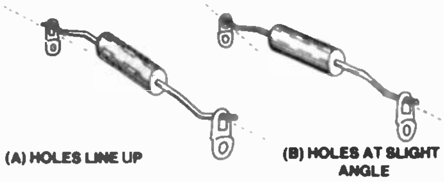

Fig. 31. Mounting component leads where the tag holes line up, or nearly so. Bend the leads to provide some slack.

To mount a component between a terminal pin and a solder tag, bend the leads around each terminal according to the principles outlined above.

When terminating several leads on one terminal, each lead should be connected separately, regardless of the type of terminal. This allows any single component to be easily removed. Don't twist the leads together as this prevents subsequent removal. **Figure 32** illustrates the correct and incorrect methods of terminating several leads to one terminal.

When interconnecting two terminals use a length of wire between them. Don't use component leads.

Mounting Components On Printed Circuit Boards

Components should always be mounted on the *non-copper* side of a printed circuit board, unless especially noted otherwise. The component leads should be inserted in the correct holes and may be formed in a variety of ways

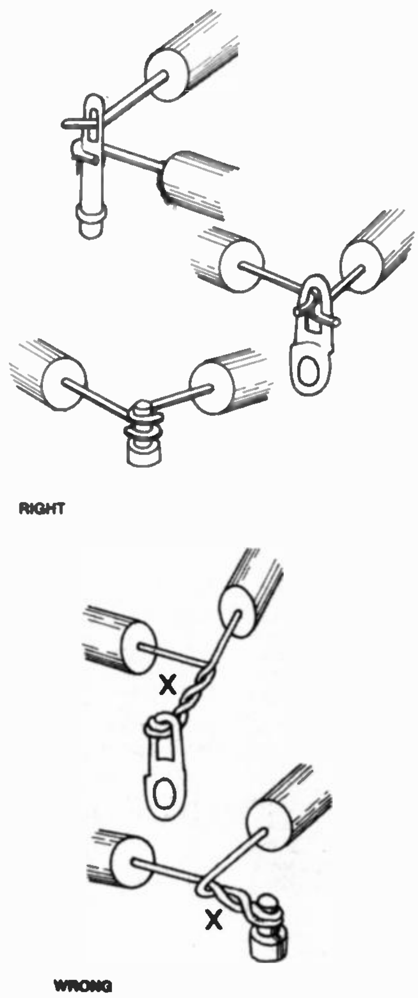

Fig. 32. When several component leads go to one terminal, attach each lead separately.

before soldering. The leads may be splayed, as shown in **Fig. 33**, to hold the components in position before soldering. This method allows all the components to be mounted before soldering. See **Fig. 34**.

Another method is to mount the components one at a time, cutting the

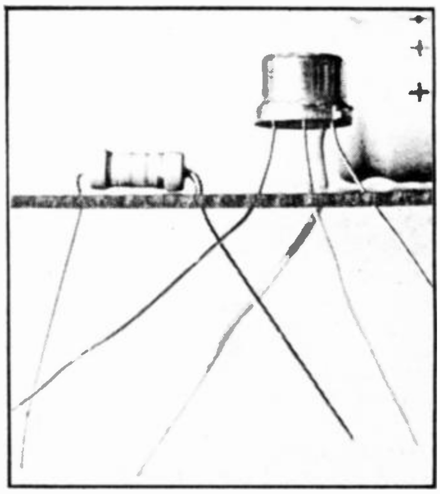

Fig. 33. When mounting components to a printed circuit board, the leads may be splayed, before soldering, to hold them in position.

leads close to the board before soldering, as in **Fig. 35**. However, this necessitates holding the component steady whilst soldering.

For a neat appearance, do not leave excessive lead length on the components; place them against the board and align them parallel to an edge. Generally, printed circuit boards are laid out so that the components will lie parallel to an edge when correctly inserted. It is a good idea to position the components so that their value and voltage rating or type number can be seen. This greatly facilitates checking and later servicing.

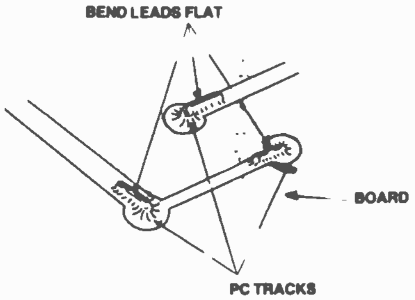

Fig. 34. The leads may be cut off and bent to lie flat along the track on the board and then soldered.

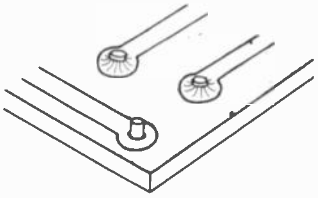

Fig. 35. Alternatively, the leads may be cut so that they protrude a short way, and then soldered. They may be cut off after soldering if you wish.

Sometimes components are mounted vertically. It is best to splay or clinch the leads in this case and allow a small clearance between the end of the component closest to the board and the board. Vertically mounted components are illustrated in **Fig. 36**.

Many capacitors, ceramic capacitors particularly, have their coating material extending a little way down the leads.

Fig. 36. Whilst axial lead components (ie resistors) are generally mounted horizontally on a PCB, they are sometimes mounted vertically. Leave a millimetre or so clearance between the bottom end and the board.

This should not be removed beyond the point where the leads enter the component body. The coating should not enter the hole in the printed circuit board. Where double-sided board is used, allow a clearance of 2 mm or so between the circuit pad and the coating on the lead.

Components with metal bodies that are mounted on the copper side of a board, or on double-sided board, or that cross a track or jumper lead should be sleeved or otherwise insulated to prevent a short circuit.

Precautions With Semiconductors

Most semiconductors are damaged by overheating. Always solder or desolder semiconductors quickly and cleanly. Make sure all parts to be joined are clean and/or tinned beforehand. If you don't feel confident about making the joint quickly, use a heat shunt (eg a pair of pliers) between the end of the lead being soldered and the transistor body to divert the heat. Special heatsink tools are obtainable for this purpose.

Integrated circuits require particular care when being soldered into printed circuit boards. If too much solder is applied, a 'solder bridge' may form between adjacent pins (see **Fig. 18**). This necessitates removing the solder, with the risk of damaging both the board and the component.

Transistors and integrated circuits of the MOS or CMOS type are easily damaged by electrostatic charges or leakage currents from the soldering iron. These devices are normally supplied with their pins inserted into a conductive material, usually a black foam. Leave them in this until they are to be used. Avoid touching the pins, as even small static discharges from the body (caused by clothing) can cause damage.

Always fit MOS or CMOS components last. Insert the device into place quickly. Solder the power supply pins first. The devices are built so that this activates built-in protective circuitry. The remaining pins may then be soldered with little chance of damage. Sockets for ICs are worth using as they remove the necessity of soldering directly to the IC pins, thus reducing the possibility of damage.

To reduce leakage currents produced by a soldering iron, connect a flexible lead from the metallic part of the iron (make sure it connects to the tip) to an alligator clip that can be attached to the equipment earth (0 V rail). Soldering irons that use a step-down transformer should have an earthed electrostatic shield between the windings. It is wise to check this when buying. Alternatively with an iron that has sufficient heat capacity, disconnect the iron when soldering components that are sensitive to leakage currents.

Desoldering

Where joints have to be desoldered there are two basic methods that can be used to effectively remove the solder — 'soaking' it up and sucking it up.

It is possible to remove leads while the solder is molten by just heating the joint. However, this is not the best

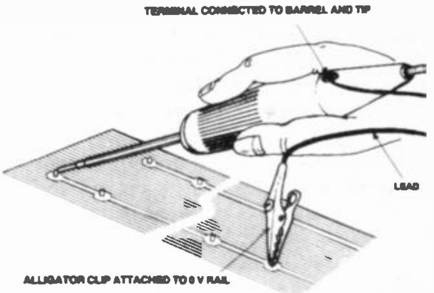

Fig. 37. A precaution to take when using mains-operated or unprotected low-voltage irons on MOS components is to connect the metallic part of the iron to the 0 V rail of the equipment with a clip lead.

method, as a component may be damaged by the amount of heat produced. Also, flexing the leads whilst trying to remove the component may damage the lead or the lead-body seal. A terminal or printed circuit can also be damaged by heat or attempts to prise the component loose while the solder is molten. It is much better to use a desoldering aid.

Desoldering 'wick' can be used to soak up molten solder from a joint. This consists of a copper braid impregnated with resin. When applied to a joint and heated with a soldering iron, molten solder from the joint flows into the fluxed braid by capillary attraction, effectively clearing the joint of solder. **Figure 38** shows how it's done.

You lay the wick over the area to be desoldered. The iron is applied to the wick and some pressure applied. As the wick heats up it activates the flux in it, which flows onto the joint, and as the solder on the joint melts it replaces the flux in the wick, flowing into the braid quite quickly. The 'used' wick is cut off afterwards. A tip running at a higher temperature and having more heat capacity than generally used for soldering is recommended. Desoldering wick is excellent for general use and on joints having a large area.

Sucking up the solder with a suitable tool is a very effective method. Hand-

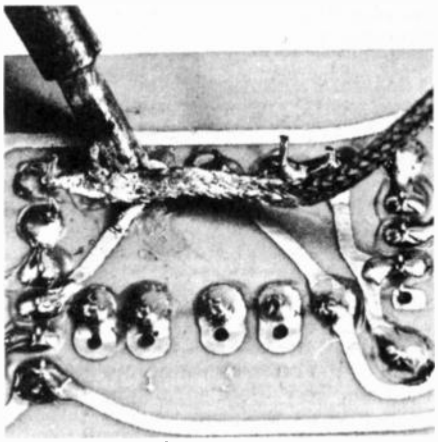

Fig. 38. How to use desoldering wick. Lay it over the joint and apply the iron tip to the braid, using a little pressure. When the solder is drawn into the braid, remove the iron and the braid.

held 'solder suckers' are inexpensive and popular but a variety of desoldering irons with suction devices incorporated are also available.

Solder suckers have a spring-loaded plunger in a barrel with a thumb-operated release mechanism. A heat-resistant nozzle at one end is applied to the joint, which is heated with an ordinary soldering iron. When the plunger is released, molten solder from the joint is drawn into the barrel. **Figure 39** shows how it's done. They are excellent for general use with PCBs. boards.

That's the general technique, and it's fine for equipment using bipolar

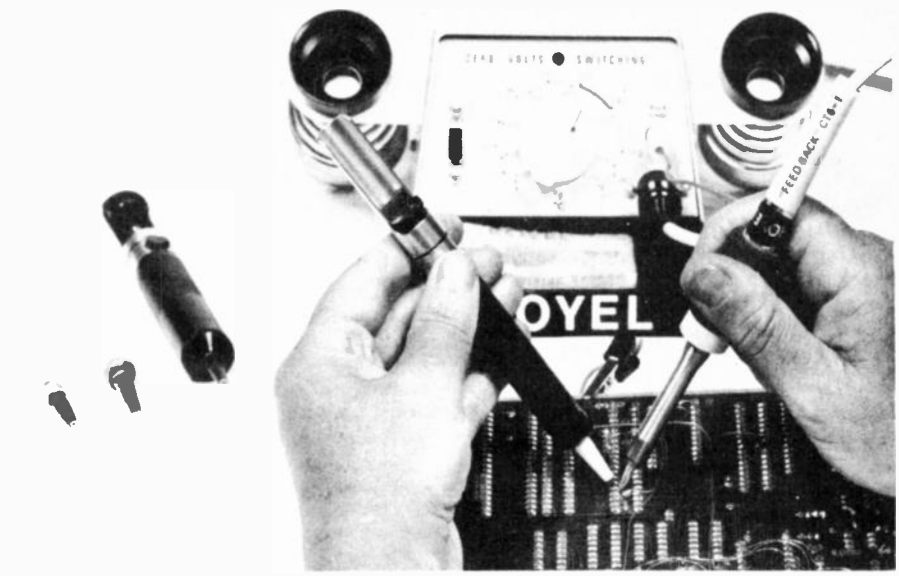

Fig. 39. Using a hand-held solder sucker. The nozzle is made of Teflon (PTFE), a heat-resistant plastic, and is replaceable. To use it, load the plunger in the tool. Heat the joint until the solder melts, apply the sucker's nozzle to the joint and release the plunger.

Fig. 40. This Hakko 'Vac Ace' desoldering tool from G.E.S. employes a small vacuum pump to draw molten solder from the joint into the glass barrel atop the gun handle. A steel wool wad absorbs the solder. This tool is particularly effective on through-hole plated PCBs.

devices, but it can be extremely dangerous for MOS devices. A US maker of solder suckers, Anderson Effects, points out that standard plastic solder suckers have been found to produce a static surge of 5 kV to 10 kV at the tip. This is invariably in contact with the device's leads when the surge occurs and may damage or destroy the device. To obviate the problem static-free metallised plastic nozzles may be obtained. Otherwise, use desoldering wick or a vacuum-operated desoldering iron.

A variety of desoldering irons having a hollow tip through which the molten solder is drawn by a vacuum pump are available. These are particularly useful for servicing work. An example is shown in Fig. 40. **HE**

(Material for preparing this article was derived from Australian Post Office technical training publication ETP 0276, 1972, and The Art of Soldering, ETI April 1975. Additional material and photographs were kindly supplied by Royston Electronics, Multicore Solders Pty Ltd, The Cooper Tool Group Ltd, Scope Laboratories and General Electronic Services.)

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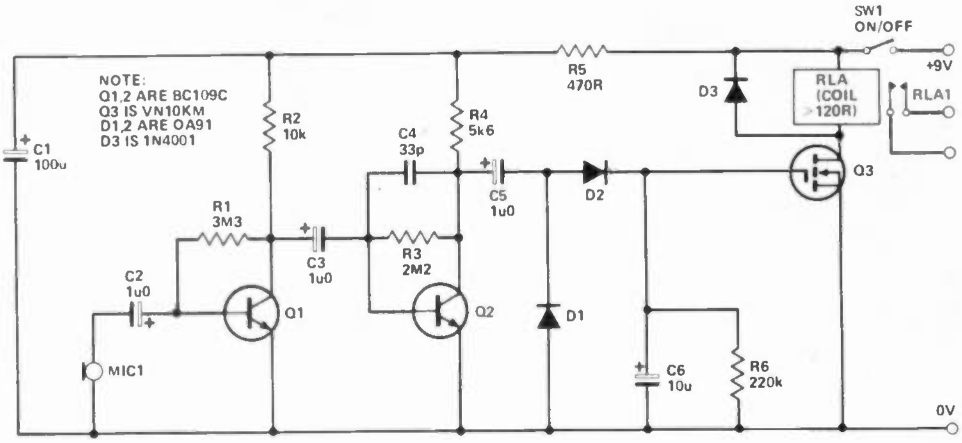
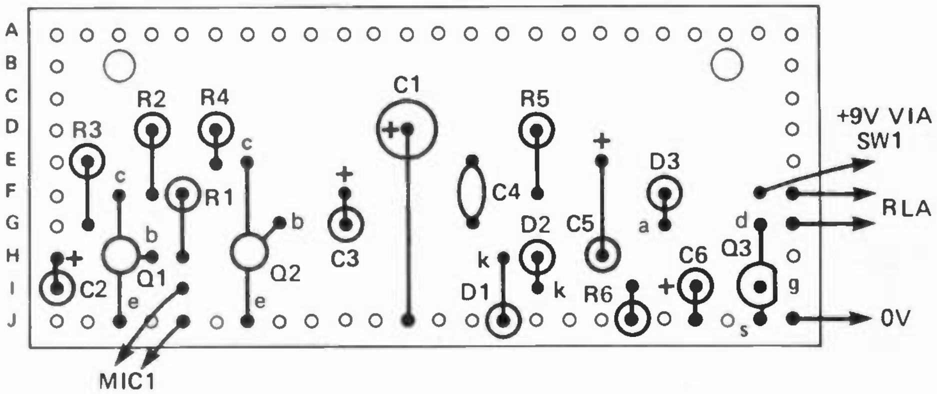
Signals from the microphone will be at a very low level and must be greatly amplified in order to operate a switching device of some kind (a relay in this case). The microphone signals are therefore coupled, by C2, to a high gain common emitter amplifier using Q1, collector load resistor R2 and base bias resistor R1. The signal level at the collector of Q1 is still inadequate, so a further and virtually identical stage of amplification is used to boost it further. The second stage is based on Q2, with C4 to attenuate the high frequency response of the amplifier and thus aid stability.

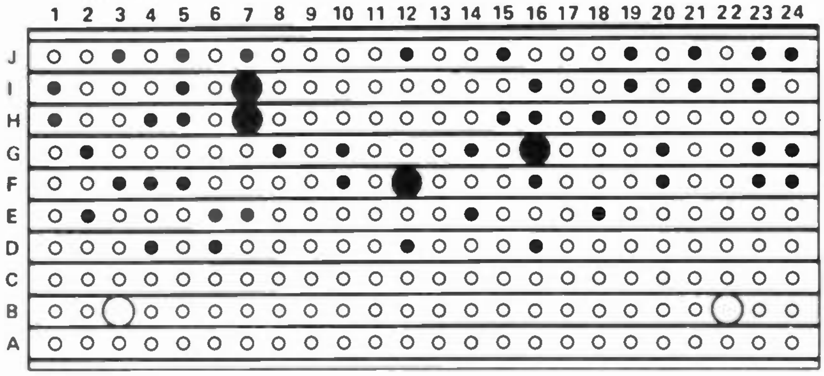
C5 couples the output of Q2 to D1 and D2 which rectify the signal to give a series of positive pulses. These are smoothed by C6 to give a positive DC bias. In the absence of an input signal there will, of course, be no significant drive, and VMOS switching transistor Q3 will be cut off. The drive will be of the order of a couple of volts or so when the unit is activated, switching on Q3 and the relay which forms its collector load. A pair of normally open relay contacts then operate the external equipment.

R6 is included so that the bias decays about two seconds after the input signal has ceased and the unit reverts to the 'off' state. Without R6 the unit would tend to latch 'on', since the input resistance of Q3, unlike an ordinary bipolar transistor, is extremely high. The attack time of the unit is very short and it switches on rapidly at the start of a signal.

The 0.1" matrix stripboard layout for the Sound Switch is straight-forward. Q3 requires no special handling precautions as it has an integral zener diode which protects it from high static charges. D1 and D2 are germanium devices and care should be taken to avoid overheating these when connecting them.







Parts List

RESISTORS (all ¼ W 5%)

R1	3M3
R2	10k
R3	2M2
R4	5k6
R5	470R

CAPACITORS

C1	100u 10 V axial electrolytic
C2,3,5	1u0 25 V axial electrolytic
C4	33p ceramic plate
C6	10u 10 V axial electrolytic

SEMICONDUCTORS

Q1,2	BC109C
Q3	VN10KM
D1,2	0A91
D3	1N4001

MISCELLANEOUS

SW1	SPST toggle switch
MIC1	microphone or high impedance loudspeaker (see text)
RLA	relay 6/12 V coil 185 ohms or more
0.1"	matrix board, PP9 or similar battery, battery clips, etc.

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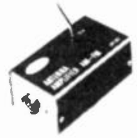

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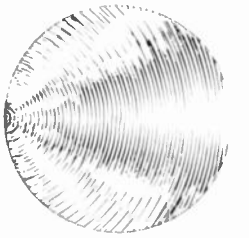

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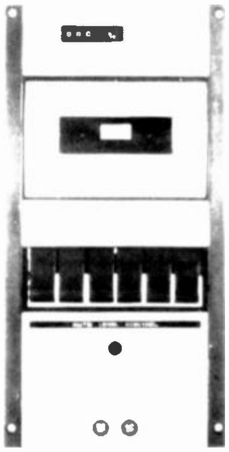
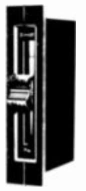


STEREO CASSETTE TAPE DECK MODULE. Comprising of a top panel and tape mechanism coupled to a record/play back printed board assembly. Supplied as one complete unit for horizontal installation into cabinet or console of own choice. These units are brand new, ready built and tested.
Features Three digit tape counter. Auto stop. Six piano type keys, record, rewind, fast forward, play, stop and eject. Automatic record level control. Main inputs plus secondary inputs for stereo microphones. **Input Sensitivity** 100mV to 2V **Input Impedance** 68K **Output level** 400mV to both left and right hand channels. **Output Impedance** 10K **Signal to noise ratio** 45dB **Wow and flutter** 0.1 **Power Supply requirements** 18V DC at 300mA **Connections:** The left and right hand stereo inputs and outputs are via individual screened leads, all terminated with phono plugs (phono sockets provided). **Dimensions** Top panel 5½in x 11¾in. Clearance required under top panel 2¼in. Supplied complete with circuit diagram and connecting diagram. Attractive black and silver finish.
Price £26.70 + £2.50 postage and packing.
Supplementary parts for 18V D.C. power supply (transformer, bridge rectifier and smoothing capacitor) £3.50



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●Rolled fabric surround ●Twin cone ●8ohm impedance ●15 watt RMS ●1" voice coil ●13oz magnet ●Frequency range 50 - 15000Hz

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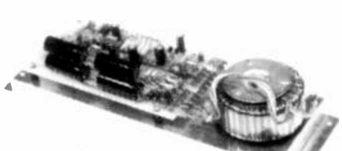
NEW RANGE QUALITY POWER LOUDSPEAKERS (15", 12" and 8") These loudspeakers are ideal for both hi fi and disco applications. Both the 12" and 15" units have heavy duty die cast chassis and aluminium centre domes. All three units have white speaker cones and are fitted with attractive cast aluminium ground finish fixing escutcheons. Specification and Price.

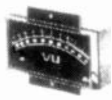
15" 100 watt R.M.S. Impedance 8ohm, 59 oz magnet, 2" aluminium voice coil. Resonant Frequency 20Hz. Frequency Response to 2.5KHz. Sensitivity 97dB. **Price £32 each** + £2.50 Packing and Carriage each.

12" 100 watt R.M.S. Impedance 8 ohm, 50 oz magnet, 2" aluminium voice coil. Resonant Frequency 25Hz. Frequency Response to 4KHz. Sensitivity 95dB. **Price £23.70 each** + £2.50 Packing and Carriage each.

8" 50 watt R.M.S. Impedance 8 ohm, 20 oz magnet, 1" aluminium voice coil. Resonant Frequency 40Hz. Frequency Response to 6KHz. Sensitivity 92dB. Also available with black cone and black protective grill. **Price £8.90 each** + £1.25 Packing and Carriage each.

OMP POWER AMPLIFIER MODULES





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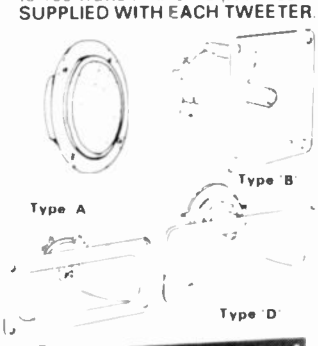
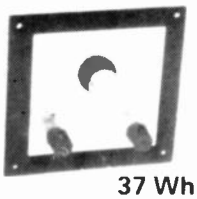
100 AND 150 WATTS R.M.S.
Power Amplifier Modules with integral toroidal transformer power supply and heat sink. Supplied as one **complete** built and tested unit. Can be fitted in minutes. Auxiliary stabilised supply and drive circuit incorporated to power an L.E.D. V.u. meter available as an optional extra.
SPECIFICATION
Max output power 100 watts R.M.S. (OMP100)
150 watts R.M.S. (OMP150)
Loads (Open and short circuit proof) 4-16 ohms
Frequency Response 20Hz - 25KHz + 3dB
Sensitivity for 100 watts 500mV at 10K
150 watts 500mV at 10K
T.H.D. 00.1%
Size 360 x 115 x 80mm

Prices			P&P
	OMP 100W	£29.99	
	OMP 150W	£39.99	£2.00
	V.u. Meter	£6.50	

PIEZO ELECTRIC TWEETERS — MOTOROLA
Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover **is not** required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**



Type 'A' 3in round with removable wire mesh. Ideal for bookshelf hi fi speakers. **Price (Type 'A') £3.45 each.**
Type 'B' 3½in super horn. For general purpose speakers, disco and PA systems, etc. **Price £4.35 each.**
Type 'C' 2in x 5in wide dispersion horn. For hi fi systems and quality disco etc. **Price £5.45 each.**
Type 'D' 2in x 6in wide dispersion horn. Frequency response extending down to mid range (2000Hz). Suitable for hi fi systems and quality disco. **Price £6.90 each.**
U.K. post free (or SAE for Piezo leaflets).



Piezo Level Control Loudspeaker Terminals [illegible] wire wound potentiometer and resistor network. A mounted on a smart brushed aluminium plate. Fits neatly through a 3" x 3" cut out on rear of speaker cabinet. Price **£2.99** + 20p postage and packing.

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Build a quality 60watt RMS system 8ohms
Build a quality 60 watt R.M.S. system

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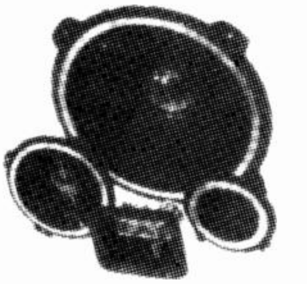
- ★ 3" Tweeter
- ★ 5" Mid Range
- ★ 3 way crossover

[illegible]
Price £22.00 per kit + £2.50 postage and packing. [illegible]



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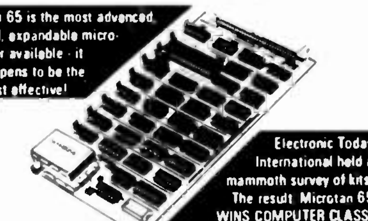

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MICROTAN 65 CONTENTS

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The MICROTAN 65 kit has won widespread acclaim for its superb presentation We pay attention to detail

KIT FORM **£69.00** + £10 35 V A T total £79 35

MICROTAN 65 assembled and tested

Specification as above but assembled and fully bench tested by ourselves

£79.00 + £11 85 V A T total £90 85

TANBUG V2.3 KIT (Separately) **£21.85** incl

MICROTAN 65 OPTIONS

LOWER CASE PACK

Two integrated circuits which connect into locations on MICROTAN allowing 128 displayable characters

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MINI MOTHER BOARD

Used to connect Microtan to Tanex

£10.00 + VAT

GRAPHICS PACK

Five integrated circuits which connect into locations on MICROTAN allowing the display of chunky graphics (64 × 64 pixels) What are chunky graphics? Well imagine a piece of graph paper with 64 squares vertically and 64 squares horizontally a total of 4096 Each square can be made black on white

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20 WAY KEYPAD

Inexpensive means of getting up and running Uses Schoeller key switches and connects to MICROTAN through a 16 pin D I L plug on ribbon cable Black anodised escutcheon with TANGERINE legends finishes off what must be the best value for money keypad available Available assembled and tested

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MPS 1 Input 120 or 240V AC Output 5 Volts at 3 Amps Regulated MPS 1 will power both MICROTAN and TANEX fully expanded Built on the same size printed circuit board as MICROTAN etc Available as a fully built and tested unit

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We have produced a mini system rack which accepts MICROTAN 65 TANEX and our mini mother board It has an integral power supply just plug it into the mains and away you go! Finished in TANGERINE BLACK it gives your system the professional finish Front panel access for I O cables AVAILABLE AS AN ASSEMBLED UNIT

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FULL MANUALS: MICROTAN–TANEX–BASIC–X BUG ALL £5.00 EACH

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Available now tanram - 40K Bytes on one board Single board of bulk memory offering 7K Static RAM (2114) and 32K Dynamic RAM (4116) Onboard refresh is totally transparent to CPU operation and is unaffected by normal DMA s TANRAM fully expands the available address space of the 6502 microprocessor MICROTAN TANEX and TANRAM together provide 16K RAM 48K RAM and 1K I O that s a lot of memory and a lot of I O! Built and tested TANRAM ASSEMBLED

40K RAM CARD with 16K DYNAMIC RAM £76 + VAT

CONTENTS High quality plated thru hole printed circuit board solder resist and silk screened component identification Full complement of I C sockets for maximum expansion 64 way D I N edge connector 1K RAM (2114) Data bus buffering TANRAM users manual

EXTRA RAM

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2708 £3 50

2716 £5 50

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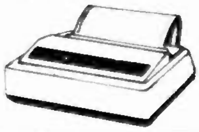

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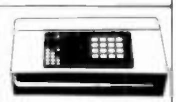

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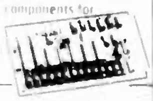
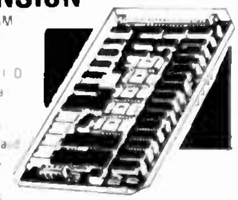


TANEX Minimum configuration Assembled

£53.00 + V A T £7 95 total £60 95

TANEX EXPANSION



Expanded TANEX offers 7K RAM locations for 4K EPROM (2716) locations for 10K extended MICROSOFT BASIC 32 parallel I O lines two TTL serial I O ports a third serial I O port with RS232 20mA loop full modem control and 16 programmable baud rates four 16 bit counter timers cassette interface data bus buffering and memory mapping

EXPANDED TANEX KIT (Excludes ROM XBUG and BASIC)

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